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# NUCLEAR SCIENCE ABSTRACTS

# CHEMISTRY

## Analytical Chemistry

*Refer also to abstracts 17712, 17744, and 18259.*

**17317** (EUR-4086) THE ANALYSIS OF ORGANIC COOLANTS FOR NUCLEAR REACTORS. Final Report. Geiss, F. (ed.) (Farbenfabriken Bayer A. G., Leverkusen (West Germany). Societe Progil, Decines (France)). Sept. 24, 1968. 178p. (In German). Dep.

Analysis of organic reactor coolants for ash, iron, nickel, boron, chlorine, sulfur, oxygen, water, and the main organic components is described. All methods studied and results are given along with a critical discussion of circular analysis. Experimental conditions of recommended analyses are included. The error statistics involved are surveyed. (auth)

**17318** (UCRL-50555) CHEMICAL ANALYSIS OF SAMPLES FROM INTEROCEANIC CANAL ROUTE 17. Hill, John H. (California Univ., Livermore. Lawrence Radiation Lab.). Dec. 1968. 66p. Dep. CFSTI.

Data are presented on the chemical analysis of core samples taken along the Atlantic-Pacific Interoceanic Canal Route 17. Sampling procedures, analytical methods, sources of contamination and the accuracy of analytical results are discussed. Four sets of analyses from two laboratories are compared, and the significance of the comparisons is discussed. (auth)

**17319** HEMIJSKE I FIZICKOHEMIJSKE METODE ANALIZA NUKLEARNIH MATERIJALA. (Chemical and Physical Methods for Nuclear Material Analysis). Beograd, Savezna Komisija za Nuklearnu Energiju, 1967. 264p.

Extensive data are given on various analytical methods for nuclear material determination. Gravimetric and volumetric methods, electrochemical, spectrophotometric, and fluorometric methods, and spectrographic, roentgenographic, and gas-chromatographic methods are discussed. Mass spectrometry, densimetric isotope methods, and activation analyses are also described. (R.V.J.)

### Chemical Procedures

**17320** (AERE-R-5927) AN IMPROVED POTENTIOMETRIC TITRATOR. Wood, A. J.; Causer, R.; Milner, G. W. C. (Atomic Energy Research Establishment, Harwell (England)). Oct. 1968. 11p. Dep. CFSTI. UK 2s. 6d.

An improved automatic potentiometric titrator is described in which the piston of a syringe-type burette is driven by a stepping motor. An Agla micro-burette is used for volumes up to 0.5 ml, and a Kontes burette for volumes between 0.5 and 2.5 ml. A total of 25,000 impulses to the stepping motor is needed to displace the full volume of solution from each burette, and an accurate measure of the volume of titrant delivered at any instant can be obtained from the number of input pulses, counted electronically. The speed of the stepping motor can be adjusted so that delivery of the full volume takes place in a time interval between 2 and 35 minutes. Potential changes at the indicator electrode are amplified and used to operate a trigger circuit which controls the input pulses to the stepping motor. The control unit allows delivery of titrant to take place until it detects a rate of change of potential which is greater than a selected value. Delivery of titrant is then halted temporarily by stopping the motor. When the rate of change of potential falls, the control unit resets electronically and the motor commences to deliver more titrant to the cell. By this means the addition of titrant can be interrupted several times on passing through the vicinity of the end-point of a titration, and at each interruption a record of the titrant delivered is automatically printed out. A chart recorder coupled to the drive of the stepping motor provides a visual record of the progress of each titration. A precision of 0.04% ($1\sigma$) was obtained for the direct titration of 0.1N solutions of ferrous ammonium sulphate with ceric sulphate, and this precision was increased to 0.01% ($1\sigma$) by the application of a back titration procedure. (auth) (UK)

**17321** (AERE-R-5937) COMPARISON OF METHODS FOR THE DETERMINATION OF NITROGEN IN TITANIUM CARBIDE. Parker, A.; Healy, C.; Henderson, E. H. (Atomic Energy Establishment, Harwell (England)). Oct. 1968. 9p. Dep. CFSTI. UK 2s. 6d.

Vacuum fusion, pyrohydrolysis, Kjeldahl, and Dumas methods were applied to the determination of nitrogen in titanium carbide. The Dumas method gave satisfactory results, but for control purposes the Kjeldahl method using sulphuric acid–sodium selenite digestion might also be used. Results obtained by the other techniques investigated were low. (auth) (UK)

**17322** (AWRE-O-42/68) EFFECTS OF SAMPLING AND SAMPLE PRETREATMENT ON THE DETERMINATION OF CARBON IN URANIUM METAL. Aldersley, K.; Cripps, F. H. (Atomic Weapons Research Establishment, Aldermaston (England)); Sawyer, A. E. (United Kingdom Atomic Energy Authority, Springfields (England). Production Group). July 1968. 21p. Dep. CFSTI. UK 4s. 0d.

Investigations show that the method of cutting the sample, its thickness, and the carbon level in the material, all affect the results obtained in the determination of carbon in uranium. (UK)

**17323** (CEA-R-3611) STUDY OF URANIUM(VI) IN CARBONATE SOLUTION BY POTENTIOMETRIC TITRATIONS AND ION-EXCHANGE. Billon, Alain (Commissariat a l'Energie Atomique, Fontenay-aux-Roses (France). Centre d'Etudes Nucleaires). 1968. 99p. (In French). Dep.

Thesis. Submitted to Univ., Paris.

A study was made concerning the fixation of uranium(VI) on the conventional anion exchange resin Dowex 2 × 8 in carbonate and hydrogenocarbonate media. Both media were successfully used for the recuperation of uranium(VI) from very dilute solutions. Equilibrium constant of the exchange $[UO_2(CO_3)_3^{4-}]_S + {}_2[CO_3^{2-}]_R \rightleftharpoons [UO_2(CO_3)_3^{4-}]_R + {}_2[CO_3^{2-}]_S$ is determined for carbonate range 0.1 M to 0.6 M from partition curves. A marked increase in the relative fixation of uranium occurs with the increase of free carbonate concentration of the solution, or the decrease of the uranium concentration. A study of the fixation of molybdenum shows that it is possible to separate the latter from uranium by elution, the carbonate concentration being molar. The possibility of separation on a larger scale is suggested based on molybdenum displacement by uranium in hydrogenocarbonate medium. (auth)

**17324** (CEA-R-3634) STUDY AND COMPARISON OF ANALYTICAL METHODS FOR DETERMINING MOLYBDENUM IN URANIUM–MOLYBDENUM ALLOYS. Buffereau, Michel; Genty, Claude; Houin, Colette; Lavaud, Michel; Leclainche, Claude; Levrard, Jocelyn; Pichotin, Bernard; Robichet, Jacques (Commissariat a l'Energie Atomique, Bruyeres-le-Chatel (France). Centre d'Etudes Nucleaires). Nov. 1968. 78p. (In French). Dep.

Various methods were developed to determine molybdenum in uranium–molybdenum alloys: molecular absorption spectrophotometry, emission spectroscopy, x-ray fluorescence, and atomic absorption spectrophotometry. A comparison was made of methods for samples in which the molybdenum content lies between 1 and 10 wt %. (auth)

**17325** (MSAR-69-28) EFFECT OF HIGH TEMPERATURE SODIUM ON THE MECHANICAL PROPERTIES OF CANDIDATE ALLOYS FOR THE LMFBR PROGRAM. TOPICAL REPORT NO. 11. ANALYSIS OF OXIDES IN SODIUM VIA SURFACE TENSION MEASUREMENTS. Roehlich, Ferdinand; Rankin, Robert L. (MSA Research Corp., Evans City, Pa.). Feb. 1969. Contract AT(11-1)-765. 23p. Dep. CFSTI.

Studies were made on the possibility of measuring oxygen in sodium by surface tension measurements using the maximum-bubble-pressure method. The results demonstrated that the greatest change in surface tension due to oxygen impurity occurs in the temperature range from the melting point to 500°F. It was concluded that soluble oxygen changes within the solubility limits may have a measurable effect on apparent surface tension as determined by the maximum-bubble-pressure method. Because of inherent limitations of the experimental device used, it was difficult to compare results of clean versus contaminated sodium. However, the results do indicate that dissolved and/or undissolved oxygen do produce a significant change in apparent surface tension. No quantitative conclusions could be made on the effect of dissolved oxygen on surface tension with the experimental apparatus used. (P.C.H.)

**17326** SPECIFIC DETERMINATION BY ATOMIC ABSORPTION OF POTASSIUM, RUBIDIUM, AND CESIUM IN THEIR MIXTURES. Merbach, A.; Gonella, J. (Univ., Lausanne, Switzerland). Chimia (Aarau), 23: 34-5(Jan. 15, 1969). (In French).

Potassium, rubidium and cesium were determined in mixtures of their salts by atomic absorption spectrophotometry. This method allows the fast and easy determination of cesium with a precision better than 5%, rubidium 2%, and potassium 2.5% by use of appropriate buffers. (auth)

**17327** QUANTITATIVE THIN-LAYER CHROMATOGRAPHY ON LIQUID ANION EXCHANGERS. PART II. A COMPARISON OF A SPOT REMOVAL METHOD WITH AN IN SITU DIRECT DENSITOMETRIC METHOD. Graham, R. J. T.; Bark, L. S.; Tinsley, D. A. (Univ. of Salford, Eng.). J. Chromatogr., 39: 218-27(Jan. 28, 1969).

The quantitative determination of metal ions separated by thin-layer chromatography using Primene JM-T hydrochloride as the stationary phase and hydrochloric acid solutions as the mobile phase was investigated. A spot removal technique used in conjunction with absorptiometric analysis is comparable in accuracy with a direct densitometric technique. The latter, however, permitted a larger range of metal ions to be investigated than did the former. It is also quicker. No loss of accuracy of the latter technique occurs when mixtures are investigated. A mixture of Zn(II)–Cd(II) (1:1, w/w) was analyzed with an accuracy of ±4% at the 1 μg level. A similar accuracy is reported for the analysis of Co(II) in an Fe(III)–Co(II) (99:1, w/w) mixture. (auth)

**17328** SPECTROPHOTOMETRIC DETERMINATION OF TRACE AMOUNT OF ALUMINUM IN HIGH-PURITY THORIUM COMPOUNDS. Chan, Kwok-yuen; Sun, Pu; Tam, Ton-poi Hua Hsueh, No. 1, 1-6(Mar. 1968).

In the method described for assay of small amounts of Al in Th, the nitrate solution of the Th compound is adjusted to 6N $HNO_3$ acidity and most of the Th is removed by tributyl phosphate–chloroform extraction. After the addition of acetic acid and oxine the pH of the solution is adjusted to 2 with $NH_4OH$, and the Fe–oxine complex is extracted with chloroform. The water layer is brought to pH 5.1 ± 0.1 for the extraction of Al–oxine with chloroform from which Cu and Ni are removed by washing with $(NH_4)_2CO_3$–KCN solution. Photometric measurements are made at wavelengths of 385 and 450 mμ and from the absorbance of Al and Cr their contents are calculated. Since Fe–oxine complex is quantitatively extracted with chloroform at pH 2.0, Fe can also be determined by measuring the absorbance at 465 mμ. In this method 10 g of sample is treated and as little as 0.2 ppM of Al can be determined. (BBB)

**17329** UTILIZATION OF A LASER IN ISOTOPIC ANALYSIS OF A DLi SAMPLE. Langer, P.; Pin, B.; Tonon, G. (CEA, [Paris]). Rev. Phys. Appl., 3: 405-13(Dec. 1968). (In French).

Isotopic analysis of a DLi specimen was performed using a Q-switched laser beam. Ion species are selected with an electrostatic analyzer. The ratio $\eta$ = (number of hydrogen atoms/number of deuterium atoms) was studied for a series of laser impacts as a function of the depth of the vacuum machined DLi target. (auth)

**17330** POSSIBILITIES OF A BAND SPECTROSCOPIC ISOTOPIC ANALYSIS OF SULPHUR. Mueller, G.; Meier, G. (Institut fuer Stabile Isotope, Leipzig). Spectrochim. Acta, Part B, 24: 45-52(Jan. 1969). (In German).

$^{34}S$ was determined by use of the SO bands (electronic transition $^3\Sigma-{}^3\Sigma$) which are excited by electrodeless high frequency discharges in $SO_2$ or $SO_2$–He mixtures. Using a small prism monochromator, the determination is based on comparison of the band head intensities. Interferences originating from the presence of $^{33}S$ can be avoided by resolving the rotational structure with the help of a grating spectrograph. The most suitable bands are those with head wavelengths of 2744.0 Å, 2827.4 Å, and 2915 Å. The measured isotope shifts $^{34}S^{16}O-{}^{32}S^{16}O$ for the heads of the most intense bands are given. (auth) (UK)

**17331** METHOD USING A RADIOACTIVE REAGENT IN ANALYTICAL CHEMISTRY. Krtil, Josef; Kyrs, Miroslav (Inst. of Nuclear Research, Rez, Czech.). Jad. Energ., 14: 433-42(Dec. 1968). (In Czech).

The use of radioactive reagents in analytical chemistry (the radiorelease method) is reviewed (105 references). The basis of the method is discussed and a number of specific analyses and the reagents used for them are identified. Some 80 elements, radicals, and compounds are listed which may be determined by the use of radioactive reagents, together with the radioactive element(s) used, the reaction involved, and the sensitivity, precision, and source of information. The radiorelease method is used in combination with physical and chemical separation methods, e.g., organic solvent extraction. The method is considered by the authors to be simple, rapid, sensitive, and adaptable to automation. (TTT)

**17332** ELECTROMETRIC STUDIES ON RARE-METAL DYE COMPLEXES. PART I. POLAROGRAPHIC ESTIMATION OF ZIRCONIUM(IV) USING ERIOCHROME BLACK T (E.C.B.T.) IN ALKALINE MEDIUM. Malik, Wahid U.; Gupta, Hari Om; Sharma, T. C. (Univ. of Roorkee, India). J. Polarogr. Soc., 14: 109-12(1968).

Investigations on the polarographic reduction of E.C.B.T. over the pH range 2.0 to 11.6 are reported. A single, reversible, diffusion controlled, one electron wave was observed over the entire pH range, and another irreversible step above pH 9.0 was also obtained. A method for the estimation of Zirconium(IV) from the reversible diffusion controlled reduction step of the 2:1 dye–zirconium complex is also reported. A probable mechanism for the formation of the complex and its subsequent reduction is proposed. (auth) (UK)

**17333** THE SPECTROPHOTOMETRIC DETERMINATION OF URANIUM(VI) WITH METHYLTHYMOL BLUE. Srivastava, K. C.; Banerji, Samir K. (Birla Inst. of Tech. and Science, Pilani, India). Microchem. J., 13: 699-704(Dec. 1968).

Uranium(VI) and methylthymol blue form a red complex in aqueous solution with maximum development of color at pH values between 6.6 to 6.8 ($\lambda$ max = 510 mμ). The net molar absorptivity is 10,625 at pH 6.7. Beer's law is obeyed in the range of 0.4 to 3.76 ppM of uranium. A procedure is described for the accurate spectrophotometric determination of uranium. The ratio of metal:ligand in the complex is 1:1. (auth)

**17334** A CRITICAL REVIEW OF ELECTROANALYTICAL METHODS FOR THE NOBLE METALS. Beamish, F. E. (Univ. of Toronto). Anal. Chim. Acta, 44: 253-86(Feb. 1969).

The published electroanalytical methods of polarography, coulometry, amperometry, potentiometry, and electrogravimetry are reviewed. For polarography, the period covered is subsequent to June 1958. For potentiometry, the reports included are in general those published after a previous review on titrimetric methods. The remaining electroanalytical methods for the noble metals have only recently received significant attention; the review of these methods, as well as the others, covers the chemical abstracts up to January 1968. During the past decade polarographic methods have taken an important place in industrial laboratories dealing with noble metals; such methods remain largely confined to simple systems although there has occasionally been some integration with other analytical techniques to allow application to complex noble metal systems. Coulometry and amperometry seem to find little application in laboratories concerned with determination of noble metals, possibly because of a lack of analytical emphasis in the reported researches. The review should make clear the paucity of industrial interest in electrogravimetric methods. (auth)

**17335** STUDIES IN THE TETRAARYLBORATES. PART IV. THE PREPARATION AND REAGENT PROPERTIES OF SODIUM TETRAKIS(m-TRIFLUOROMETHYLPHENYL)BORATE. Meisters, Marts; Moore, Carl E.; Cassaretto, Frank P. (Loyola Univ., Chicago). Anal. Chim. Acta, 44: 287-91(Feb. 1969).

Sodium tetrakis(m-trifluoromethylphenyl)borate was synthesized

and shown to be a highly selective reagent for cesium ion even in the presence of other alkali metal ions. Equivalent amounts of rubidium or potassium do not interfere. (auth)

**17336** DETERMINATION OF MOLYBDENUM BY ATOMIC ABSORPTION SPECTROSCOPY. Ramakrishna, T. V.; West, Philip W.; Robinson, J. W. (Louisiana State Univ., Baton Rouge). Anal. Chim. Acta, 44: 437-9(Feb. 1969).

An investigation of the determination of Mo by atomic absorption spectroscopy indicated that the determination of Mo in nitrous oxide–acetylene flame was subject to interference from several extraneous ions and compounds. Depending upon the ions present the interference was either an enhancement or a depression in the Mo absorption. However, the method could be made more selective by the addition of Al to the samples. The sensitivities in the absence and presence of Al were, respectively, 1 and 0.8 ppM of Mo for 1% absorption. (auth)

**17337** SPECTROPHOTOMETRIC DETERMINATION OF RUTHENIUM AS PEROXO-BIS-ETHYLENEDIAMINETETRAACETATE. Ezerskaya, N. A.; Solovykh, T. P. (Inst. of General and Inorganic Chemistry, Moscow). Zh. Anal. Khim., 24: 422-5(Mar. 1969). (In Russian).

A spectrophotometric method has been developed for determining from $6 \times 10^{-5}$ to $3 \times 10^{-4}$ M of ruthenium. The method is based on the formation of a brightly colored ruthenium(III) peroxobis-ethylenediaminetetraacetic acid. Large amounts of other Group VIII metals do not interfere. (auth)

**17338** REMOVAL OF MOLYBDENUM FROM SOLUTION BY ELECTROLYSIS WITH A MERCURY CATHODE. Golubeva, I. A. (Inst. of Metallurgy, Moscow). Zh. Anal. Khim., 24: 467-8(Mar. 1969). (In Russian).

A method is suggested for the quantitative isolation (down to 100 mg) of molybdenum from solution by means of electrolysis on a mercury cathode followed by the determination of molybdenum by one of the known methods. The method permits the separation of molybdenum from a number of other elements. (auth)

**17339** THE USE OF FOUR-LIGAND THENOYLTRIFLUOROACETONE COMPLEXES FOR THE DETERMINATION OF CERTAIN RARE EARTH ELEMENTS BY THEIR ABSORPTION SPECTRA. Kononenko, L. I.; Piontkovskaya, T. P. (Inst. of General and Inorganic Chemistry, Kiev). Zh. Anal. Khim., 24: 379-83 (Mar. 1969). (In Russian).

The absorption spectra of rare earth elements in solutions of four-ligand complexes ($MeTTA_4$) with thenoyltrifluoroacetone (TTA) or dibenzoylmethane and organic bases have been studied. For the formation of four-ligand complexes the intensification of the absorption bands which are sensitive to the ligand field was observed only for the elements at the end of the natural lanthanide series, such as Ho, Er, Tm, and Yb. Thus, these elements can be determined with higher sensitivity with the four-ligand complex than with complexes of the type ($MeTTA_3$). (auth)

## *Isotopic Procedures*

**17340** ISOTOPE DILUTION FOR WEIGHING MERCURY IN ELECTROLYTIC CHLORINE CELLS. McCabe, W. J. (Inst. of Nuclear Sciences, Lower Hutt, N. Z.). N. Z. J. Sci., 11: 270-5 (June 1968).

A method was developed for using $^{203}Hg$ to inventory the Hg content of electrolytic cells. It was tested in a large New Zealand chlorine plant where there are 12 cells producing about one million liquid tons of chlorine annually from the electrolysis of brine. To maintain its cathode each cell requires about half a ton of mercury which flows as a thin liquid sheet over the floor of the cell. Because of the value of mercury, about $8000/cell, it is necessary to take an inventory of stocks periodically. An isotope dilution technique using radioactive elementary $^{203}Hg$, which has a half-life of 47 days, was developed for measuring the quantity of mercury in the cells without disturbing their operation, and has been found to be satisfactory. By using a well-type sodium iodide crystal to count $\gamma$ rays, the activity required could be reduced to 10 mCi of $^{203}Hg$. Approximately 10 mCi of $^{203}Hg$, produced by irradiating 10 g of mercury with neutrons, was diluted with 1790 g of mercury. After thorough mixing, 100-g portions of this mercury stock, each containing 0.5 mCi, were added to each cell. The cells were then sampled at various times. (BBB)

**17341** A METHOD FOR ISOTOPIC RATIO MEASUREMENT BY VOLTAGE PEAK SWITCHING, AND ITS APPLICATION WITH DIGITAL OUTPUT. Arriens, P. A.; Compston, W. (Australian National Univ., Canberra). J. Mass Spectrom. Ion Phys., 1: 471-81(Dec. 1968).

A method is proposed for precise measurement of $^{87}Sr/^{86}Sr$ relative to a reference $^{88}Sr/^{86}Sr$ or $^{86}Sr/^{84}Sr$, made possible by peak switching using the ion-accelerating voltage, instead of the magnetic field. A simple, specific operating procedure is described which ensures that the fractional change in observed $^{87}Sr/^{86}Sr$ due to the dependence of ion intensity upon accelerating voltage will be very closely one-half the fractional change in $^{88}Sr/^{86}Sr$. The voltage-effect may therefore be corrected simultaneously with other sources of mass discrimination by normalizing the observed value of the reference ratio to a standard value. Replicate unspiked analyses of the Eimer and Amend Sr standard by this method gave a mean $^{87}Sr/^{86}Sr$ of 0.70813 for normalized $^{88}Sr/^{86}Sr$ of 8.3752, and standard error for a single analysis of 0.00015, which are both indistinguishable from the best magnet-switched data. Approximately half of the total variance is due to the observed within-run variance. Variances for $^{87}Sr/^{86}Sr$ of a shelf standard, calculated from voltage-switched isotopic ratios for mixtures of the standard with single and double Sr tracers, agreed well with the calculated magnifications of the unspiked variance arising from the dilution of the sample. (BBB)

**17342** SUBSTOICHIOMETRIC DETERMINATION OF CADMIUM BY ISOTOPIC DILUTION ANALYSIS. Kasparec, I.; Zeman, A.; Prasilova, J. (Faculty of Technical and Nuclear Physics, Prague). J. Radioanal. Chem., 2: 281-5(Mar. 1969).

A substoichiometric method, based on dithizone extraction procedures, for determination of microgram amounts of Cd in biological materials was developed using isotopic dilution analysis. The method was verified using solutions containing microgram amounts of Cd in the presence of interfering elements (Cu, Pb, Tl, Bi, Mn, Co, Ni, Zn, Ag, and Hg). The effect of the acidity was studied and the most suitable pH region for the substoichiometric separation of Cd was found to be between 8 and 11. (D.H.M.)

**17343** DETERMINATION OF PLUTONIUM BY ISOTOPIC DILUTION MASS SPECTROMETRY FOLLOWING TTA-EXTRACTION. Bokelund, H. (Eurochemic Co., Mol, Belg.). J. Radioanal. Chem., 2: 191-6(Mar. 1969).

Isotopic dilution mass spectrometry was applied to assess the plutonium concentration in samples such as those obtained from the dissolution of irradiated uranium fuels in a reprocessing plant. Prior to the analysis, plutonium is taken through a redox cycle and is separated from uranium and fission products by extraction into TTA–xylene. The extraction procedure, the standardization of the spike solution and the mass assay of the plutonium are described; typical results under plant conditions are given. The overall precision of a single measurement of the plutonium concentration is 0.6%, expected as relative standard deviation, including the plant sampling error, dilution error, and analytical error. (auth)

**17344** DOUBLE ISOTOPE DILUTION DERIVATIVE TECHNIQUE FOR TESTOSTERONE GLUCURONOSIDE IN URINE. New, Maria I.; Gross, Joel M.; Peterson, Ralph E. (Cornell Univ. Medical Coll., New York). Acta Endocrinol., 58: 77-97(May 1968).

A double isotope dilution derivative technique using $^{3}H$ and $^{14}C$ was devised for the determination of testosterone glucuronoside in urine. The $^{3}H$ and $^{14}C$ were measured simultaneously at a constant photomultiplier voltage in a scintillation spectrometer. The precision of the measurement was dependent on the ratio of tritium to carbon. For optimum precision, the $^{3}H/^{14}C$ ratio should be 0.1 to 100. The method was used to study normal prepubertal and pubertal males, normal females, and subjects with gonadal dysgenesis, Cushing's disease, and hypogonadism. The patients were studied after stimulation and suppression of gonads or adrenal glands to delineate the source of the androgen and its physiological control mechanism. The testosterone production of normal males determined by this method corresponded to results of other methods. (BBB)

## *Radiometric Procedures*

*Refer also to abstract 18019.*

**17345** (AEC-tr-7030, pp 157-62) RADIOMETRIC APPARATUS FOR DETERMINING $^{90}Sr$ CONTENT OF SEA WATER. Vakulovskii, S. M.; Silant'ev, A. N. Translation of report A-AC-82/G/L-1259.

In order to measure the content of $^{90}Sr$ separated from 2 to 10 l of seawater, sensitive radiometric equipment was developed. The equipment consists of a scintillation-type beta-spectrometer, in which for reducing background, a combined detector of the Phoswitch type was used. The detector consists of a monocrystal of naphthalene with a diameter of 25 mm and a height of 20 mm, to the end surface of which there was glued a disk made of scintillating plastic on the base of polyvinylxylol. Two detectors, mounted

on two photoelectronic multipliers of the type FEU-53, were used to form the telescopic system. The proposed device has a sensitivity exceeding by several times the sensitivity of the best known installations. (D.H.M.)

**17346** (JAERI-5017, pp 131-9) ENVIRONMENTAL SURVEY. (Japan Atomic Energy Research Inst., Tokyo). (In Japanese).

Several technical developments in the analyses of radioactive nuclides in soil were made and applied to routine monitoring. In studies relating to the environmental hazard evaluation, wind speed and atmospheric stability were analyzed statistically. The environmental hazard was evaluated for the design of several facilities and the start of operation in the establishment. The analysis of sea current in the coastal area off Tokai, which was difficult until the preceding year because of insufficient data, was made systematically. (auth)

**17347** (MLM-1400) RADIATION EMITTED BY $^{233}U$, $^{232}U$ MIXTURES. Hertz, M. R. (Mound Lab., Miamisburg, Ohio). Mar. 21, 1969. Contract AT(33-1)-Gen-53, 23p. Dep. CFSTI.

Tables and graphs are presented to aid in the use of alpha counting and alpha spectroscopy as analytical tools in chemical separation processes for $^{233}U$, $^{232}U$ mixtures. The tables and graphs present intensities and energies of alpha and gamma radiation from mixtures of $^{232}U$ and $^{233}U$. Alpha and gamma radiation due to the ingrowth of radioactive daughters are also given. Tables and graphs are also included to aid in estimating the intensity of penetrating gamma radiation. (auth)

**17348** RAPID ESTIMATION OF RADIOIODINE IN WATER SAMPLES. Haberer, Klaus; Stuerzer, Ursula. GWF (Gas-Wasserfach), 109: 1287-9(Nov. 15, 1968). (In German).

A method developed for the analysis of milk samples by Fairman and Sedlet (Anal. Chem., 38: 1171 (1966)) may be applied to the determination of radioiodine in water samples. It is based on the ion exchange of radioiodine on silver chloride columns. For the rapid determination of small amounts of radioiodine in water the simple filtration of water samples through AgCl-coated paper is suitable. The $\beta$ and $\gamma$ activity of the paper may then be measured directly. The time required for isolation of I requires 20 min, without previous treatment of the water sample and the measurement time. Influence of water volume and additives is minor; 5 filters are required to retain 99% of the I. Interference is caused by $^{36}Cl$, $^{82}Br$, and $^{110}Ag$. A more lengthy procedure for exact values of $^{131}I$ in the presence of these isotopes would include removal of I from the paper with $Cl_2$-saturated 0.1N $H_2SO_4$, two oxidation–reduction cycles, concentration, and formation of AgI again. (BBB)

**17349** METALLURGICAL APPLICATIONS OF MICRO-ANALYSIS TECHNIQUES BY DIRECT OBSERVATION OF NUCLEAR REACTIONS. Amsel, G. (Ecole Normale Superieure, Paris); David, D.; Beranger, G.; Boisot, P. Rev. Phys. Appl., 3: 373-86(Dec. 1968). (In French).

Microanalysis by means of nuclear reactions is briefly described, and compared with other microanalytical methods such as electron and ion probe, activation analysis, etc. The specific character and high sensitivity of the method are emphasized. A review follows of some applications to metallurgy, illustrated by experimental results: oxygen diffusion in zirconium and self-diffusion in zirconia (using $^{18}O$), perturbations induced by various surface treatments, influence of annealing in high vacuum, nitriding of various metals in hot ammonia, etc. The results shown are chiefly related to the determination of the isotopes of oxygen and nitrogen, but the extension of these techniques to other light elements is also approached. (auth)

**17350** MEAN RANGE OF FISSION FRAGMENTS IN SOME METALS WITH MICA AS A DETECTOR. Mory, J. (CEN, Fontenay-aux-Roses, France). Rev. Phys. Appl., 3: 387-95 (Dec. 1968). (In French).

In order to evaluate low concentration of fissile elements in alloys by means of fission fragment tracks in mica, the mean range of fission fragments is measured in a number of elements. It is found, for cold worked metals, in mg·cm$^{-2}$. Al: 2.84; Ti: 3.62; Fe: 4.22; Ni: 4.40; Cu: 5.08; Mo: 5.18; Ag: 5.40; Au: 8.50. The crystalline state of the alloy must be taken into account, and annealing increases the ranges. (auth)

**17351** MEASUREMENT OF THE HUMIDITY OF CERAMIC PASTES. Maretheu, A. (Societe Francaise de Ceramique, Paris). Bull. Soc. Fr. Ceram., No. 78, 75-8(Jan.-Mar. 1968). (In French).

A new method for the determination of moisture in ceramic pastes, based on the deceleration of fast neutrons by the H atoms of water, is described; it is accompanied by a measurement of the apparent density of the material, which is carried out by observation of the attenuation of $\gamma$ radiation. It has been applied to plastic pastes for fine ceramics, refractory materials, tile powders, and other materials. Brief descriptions of the principles of both radiation techniques are given. Results were found to be independent of the chemical composition or the granulometry of the material. There was a difference between the water found by the neutron method and that found by the classical method because the curve is not linear for water concentrations below 5%. Precision is about 0.7% for humidity and 0.4% for density. Problems remain in adapting this method to routine analysis of ceramic pastes. (BBB)

**17352** SIMULTANEOUS DETERMINATION OF URANIUM AND PLUTONIUM IN INACTIVE PUREX PROCESS SOLUTIONS BY X-RAY FLUORESCENCE. Ertel, D. (Karlsruhe Nuclear Research Center, Ger. Gesellschaft fuer Kernforschung mbH, Karlsruhe, Ger.). J. Radioanal. Chem., 2: 205-9(Mar. 1969).

By intensity measurements of the uranium and plutonium $L_{\alpha 1}$-lines these elements can be determined simultaneously either in aqueous or in organic Purex process solutions. Thorium was used as an internal standard. The sensitivity of the method is about $10^5$ cpm/mg U, Pu/ml and the detection limits are around 2 to 3 $\mu$g U, Pu/ml. The analytical range extends from 0.003 mg U, Pu/ml up to 10 mg U, Pu/ml. A time-saving routine procedure is described. Interferences detected at extreme U/Pu concentration ratios are discussed and explained. (auth)

**17353** DETERMINATION OF ACTIVITY OF $^{45}Ca$ IN SOLID SOURCES. Conceicao, Alice S.; Prazeres, Amelia R. (Inst. of Public Health and Tropical Medicine, Lisbon). Rev. Port. Quim. (Lisbon), 10: No. 1, 1-5(1968). (In Spanish).

Solid sources for $^{45}Ca$ counting were prepared using $CaCO_3$ and $CaC_2O_4$ precipitates. The self-absorption on the sources was studied, and it was found that efficiency was higher for the $CaCO_3$ sources in spite of its higher solubility product. This can be explained as a result of self-absorption. The best conditions for precipitation and filtration were also studied. (auth)

**17354** DETERMINATION OF $^{54}Mn$ IN FOODS. Davis, S.; Arnold, A.; Jordan, A. (Food and Drug Administration, Washington, D. C.). J. Radioanal. Chem., 2: 161-70(Mar. 1969).

Manganese-54 was determined in complex food ash of high cationic environment. The initial step was an extraction at pH 2.7 with hexane containing di(2-ethylhexyl) phosphate (HDEHP) to complex the $^{54}Mn$ and other nuclides. The manganese was re-extracted into an alkaline EDTA buffer, which was washed with 1% 8-hydroxyquinoline in chloroform containing 5% isoamyl alcohol. The $^{54}Mn$ was determined by gamma spectrometry with recoveries ranging from 96.6 to 99.4%. (auth)

**17355** NEW RADIOMETRIC TITRATION METHOD BASED ON SEPARATION BY MEANS OF ION EXCHANGE. I. MATHEMATICAL EXPRESSIONS FOR THE TITRATION CURVES IN COMPLEXOMETRY AND OXIDIMETRY. Heijink, A.; Polak, H. L. (Univ. of Amsterdam). J. Radioanal. Chem., 2: 235-41 (Mar. 1969).

A radiometric titration procedure is proposed, which is based on phase separation by means of an ion exchanger in the solution. The method can be applied in both complexometry and oxidimetry. A mathematical expression was derived for the titration curves in both cases. In complexometry, a straight line is possible depending on the concentration, the mass-distribution coefficient and the complex constant, while the titration curve in oxidimetry should always be a straight line. (auth)

**17356** A LIQUID SCINTILLATION COUNTING METHOD OF $^{14}C$- AND $^{3}H$-LABELED LIQUID ORGANIC ACIDS. Matsuo, Mitsuyoshi (National Inst. of Radiological Sciences, Chiba, Japan). Anal. Biochem., 26: 450-2(Dec. 1968).

N,N'-Dibenzylethylenediamine salts of some liquid organic acids (formic, acetic, glycolic, pyruvic, DL-lactic, levulinic, DL-$\alpha$-hydroxy-n-butyric, and DL-mevalonic) were prepared and the properties of the salts examined. The relative counting efficiencies of the salts were compared with those of the S-benzylthiuronium salts. It was found that the salts are suitable for liquid scintillation counting of the $^{14}C$- and $^{3}H$-labeled liquid organic acids. The advantages for liquid scintillation counting of the acids using the salts are discussed. (auth)

**17357** DRY COUNTING OF $^{32}P$ IN LIQUID SCINTILLATION COUNTERS. Huelsen, W.; Prenzel, U. (Kernforschungszentrum, Karlsruhe, Ger.). Anal. Biochem., 26: 483-4(Dec. 1968).

During studies on $^{32}P$ uptake by the green alga Chlorella, the algae were separated from the nutrition medium by filtration through glass fiber filters. These algae-covered filters were dried (10 min, 110°C), deposited in the sample vial (glass), and counted with optimum settings. From the results it was concluded that "dry" counting might be of advantage if it is intended to continue using the radioactive material on the filter. (P.C.H.)

**17358** LIQUID SCINTILLATION SPECTROMETRY OF TRITIUM-LABELED PROTEINS SEPARATED BY DISC ELECTROPHORESIS. LeBouton, A. V. (Univ. of California, Los Angeles). Anal. Biochem., 26: 445-7(Dec. 1968).

A method is described for determining radioactivity in tritium-labeled proteins separated by disc electrophoresis. The protein is first liberated from the gel by dissolving the gel with 30% hydrogen peroxide. The free protein is then brought into intimate contact with the scintillation solvent by means of a new solubilizing agent. Liquid scintillation spectrometry is used to count the samples and all steps are done in scintillation vials under conditions considered optimal for no loss of tritium radioactivity. The results of determinating radioactivity in increasing amounts of albumin-$^{3}$H are tabulated. It was found that as the amount of serum is increased there is a corresponding increase in the net activity of the serum albumin. (P.C.H.)

**17359** THE MEASUREMENT OF SOFT $\beta$-EMITTING ISOTOPES BY LIQUID SCINTILLATION COUNTING. Fodor-Csanyi, P. (Eoetvoes Lorand Univ., Budapest). Ann. Univ. Sci. Budapest, Rolando Eotvos Noninatae, Sect. Chim., 9: 25-40(1967).

The method and advantages of liquid scintillation counting for measurement of soft beta-emitting isotopes are discussed. The isotopes are tritium, $^{14}$C, $^{35}$S, and $^{45}$Ca. The scintillation mechanism, solvents, scintillators and wavelength shifters, preparation of samples, counter design, dual-channel instruments, single-channel instruments, and the role of phosphorescence in measurements with a single-channel instrument are considered. (M.C.G.)

**17360** THE MEASUREMENT OF BETA-EMITTING ISOTOPES WITH LIQUID SCINTILLATOR IN SAMPLES OF BIOLOGICAL ORIGIN. Szilagyi-Gyoeri, E.; Fodor-Csanyi, P. (Eoetvoes Lorand Univ., Budapest). Ann. Univ. Sci. Budapest, Rolando Eotvos Noninatae, Sect. Chim., 9: 41-7(1967).

Determination of $^{3}$H, $^{14}$C, $^{35}$S, $^{45}$Ca, and $^{32}$P in biological materials is described. Preparation of homogeneous solutions, suspensions, and emulsions is considered. Measuring quenchers and colored substances is discussed. (M.C.G.)

## Activation Procedures

*Refer also to abstracts 17720 and 18717.*

**17361** (CEA-R-3636) NONDESTRUCTIVE ANALYSIS OF MAJOR COMPONENTS OF PLANT MATERIALS BY MEAN OF 14-MeV NEUTRONS. Garrec, Jean-Pierre (Commissariat a l'Energie Atomique, Grenoble (France). Centre d'Etudes Nucleaires). Nov. 1968. 30p. (In French). Dep.

Small electrostatic accelerators, which generate fast neutrons of 14-MeV energy, are used for directing a deuteron beam at 150 keV onto a tritiated target. The resulting flux of monoenergetic neutrons attains $5 \times 10^{11}$ n/sec in $4\pi$ geometry by the $^{3}$H(d,n)$^{4}$He reaction. Numerous elements found in plant material can be activated in this flux, mainly by (n,p), (n,$\alpha$), and (n,2n) reactions. Current research is directed towards making use of the entire gamma spectrum of activated plant matter. A computer is used to break down the spectrum into seven main spectral regions by the least-squares method. As a first approximation, these regions are those obtained from aluminum, calcium, potassium, magnesium, phosphorus, silicon, and chlorine standards in standard activation and radioactive decay conditions. The advantage of this method of analysis is not acute sensitivity, but great speed. Therefore radioactivation with 14-MeV neutrons is particularly well adapted to quick and simultaneous determination of useful elements in agronomy. (auth)

**17362** DETERMINATION OF OXYGEN IN STEELS BY NEUTRON ACTIVATION. II. PROBLEMS SET BY THE ERECTION AND USE OF A NEUTRON ACTIVATION LABORATORY IN A STEEL PLANT. Lacomble, M.; Collette, F.; Hans, A.; Tyou, Ph. CNRM (Cent. Nat. Rech. Met.) Met. Rep., No. 13, 33-7(Dec. 1967).

Problems pertaining to the installation and use of a neutron activation laboratory in a steel plant are described. Laboratory site considerations and design, sample preparation, and safety measures are discussed. (J.G.B.)

**17363** THE ANALYSIS OF THIN FILMS FOR SILICON, OXYGEN, AND ALUMINUM BY FAST NEUTRON ACTIVATION. Persiani, C.; Cosgrove, J. F. (Bayside Lab., N. Y.). Thin Solid Films, 2: 437-44(Dec. 1968).

Neutron activation analysis employing 14.5-MeV neutrons was evaluated for application to the analysis of thin films of silicon dioxide, aluminum oxide, and mixed oxide films prepared by chemical vapor deposition (CVD). The limits of detection and the interferences due to other elements are presented. Results of some samples analyzed for silicon and oxygen by chemical methods are compared with those obtained by neutron activation. (auth)

**17364** CONCENTRATION AND DETERMINATION OF RARE EARTH IMPURITIES IN YTTRIUM MATRIX. Kulus, Eva; Molnar, Ferenc; Szabo, Elek. KFKI (Kozp. Fiz. Kut. Intez.) Kozlem., 17: 20-4(1969). (In Hungarian).

A method is presented for the anion exchange concentration of rare earth impurities of yttrium matrices and for the determination of these impurities by means of neutron activation analysis. (auth)

**17365** DETERMINATION OF MACROCOMPONENTS IN METEORITES BY NONDESTRUCTIVE ACTIVATION ANALYSIS. Csajka, Maria; Lavrukhina, A. K.; Szabo, Elek. KFKI (Kozp. Fiz. Kut. Intez.) Kozlem., 17: 25-37(1969). (In Hungarian).

A method for the nondestructive activation analysis of the macrocomponents Mg, Al, Ni, Co, Mn, Fe, and Si in meteoritic samples is described. The macrocomponents can be evaluated from the short-lived isotopes activated in samples weighing up to 2 mg. Results of the analyses are reported. (auth)

**17366** DETERMINATION OF SILICON, ALUMINUM, AND PHOSPHORUS IN BIOLOGICAL SAMPLES, BY NEUTRON ACTIVATION AND SPECTROPHOTOMETRY. Orban, Eva; Oerdoegh, Maria; Szabo, Elek; Miskovits, Gusztav; Dubay, Miklos. KFKI (Kozp. Fiz. Kut. Intez.) Kozlem., 17: 39-57(1969). (In Hungarian).

A method developed for the quantitative determination of silicon, phosphorus, and aluminium in lymphatic glands is described. Nondestructive neutron activation analysis is used to evaluate the Al concentration of the sample with a simultaneous determination of the sum of the Si and P content. The Si and P concentrations are determined individually by spectrophotometry after chemical decomposition. (auth)

**17367** DETERMINATION OF OXYGEN IN STEELS BY NEUTRON ACTIVATION. I. PRINCIPLE OF THE METHOD AND DESCRIPTION OF THE EQUIPMENT. Hoste, J.; Speecke, A.; De Soete, D. (Univ. of Ghent). CNRM (Cent. Nat. Rech. Met.) Met. Rep., No. 13, 29-32(Dec. 1967).

The reaction $^{16}$O(n,p)$^{16}$N, was used in the neutron activation analysis in steel for oxygen content. Equipment developed for the method included a generator of fast neutrons, a twin counting unit, a pneumatic conveyor system for transporting the specimens, and a control desk. The analysis is performed by a simultaneous comparison between the standard specimen and the specimen to be analyzed, and results can be calculated automatically. (J.G.B.)

**17368** DETERMINATION OF OXYGEN IN STEELS BY NEUTRON ACTIVATION. III. RESULTS OF THE EXPERIMENTS CARRIED OUT IN THE FIRST HALF OF 1967 WITH THE EQUIPMENT INSTALLED AT THE LD STEEL PLANT OF S. A. COCKERILL-OUGREE-PROVIDENCE. Hans, A.; Tyou, Ph.; Lacomble, M.; Collette, F. CNRM (Cent. Nat. Rech. Met.) Met. Rep., No. 13, 37-46(Dec. 1967).

A statistical study on the performance of a neutron activation method for analysis of steel for oxygen was carried out on more than 2,000 out of 20,000 completed determinations. Analysis of the three groups of reference specimens was repeated several times. Results are sufficiently reproducible to warrant their metallurgical use. (J.G.B.)

**17369** DETERMINATION OF TRACES OF LIGHT ELEMENTS BY ACTIVATION WITH $\gamma$ PHOTONS AND CHARGED PARTICLES. Cabane, G.; Engelmann, Ch. (CEN, Saclay, France). Rev. Phys. Appl., 3: 365-72(Dec. 1968). (In French).

Radioisotopes such as $^{11}$C, $^{13}$N, $^{15}$O, $^{18}$F can be produced by photons or charged particle activation, and so allow the detection and analysis of light elements at levels of $10^{-6}$ to $10^{-9}$. Because of this extreme sensitivity and the possibility of getting rid of surface contamination, these types of activation analysis are unchallenged for very high purity materials, and indeed they already have given results (for O, C, N in Si, Fe, and Nb for example) that cannot be obtained by any other method. Applications for semiconductors as well as metals are mushrooming as cyclotrons and linear accelerators become progressively more accessible. If the technical advance of French teams can be maintained, this will be a very important factor for the development of new semiconductor materials and for the success of many studies in physical metallurgy. (auth)

**17370** ACTIVATION ANALYSIS. Webster, R. K. (Atomic Energy Research Establishment, Harwell, Eng.). Engineering, 207: 365-8(Feb. 28, 1969).

The principles and methods of activation analysis are outlined. Applications considered include trace analysis, analysis of intact samples, on-line analysis, and surface and element location studies. The necessary instrumentation and its cost are briefly summarized. (UK)

**17371** PRECISION AND ACCURACY OF SODIUM DETERMINATION BY NEUTRON ACTIVATION. Parker, Ronald B.; Brunfelt, Arild O. (Univ. of Wyoming, Laramie). Chem. Geol., 3: 213-17(Sept. 1968).

Replicate analyses for Na were performed on 2 rock powders to evaluate the precision and accuracy of instrumental reactor neutron activation analysis for Na in common rock types. Standards and unknown samples were irradiated together in the JEEP I reactor at the Institutt for Atomenergi, Kjeller, Norway, at a thermal flux of about $2.5 \times 10^{12}$ n/cm$^2$ sec for ~5 min and allowed to cool for 1 day before activity measurement. A 400-channel analyzer with a 2 × 2 in. NaI(Tl) crystal was used for selective counting of γ activity. The area of the 2.75-MeV photopeak of 15.0-hr $^{24}$Na was evaluated. For samples irradiated in plastic envelopes, giving the lowest sample standard deviation (1.2%), the sample standard deviation reduced by the estimated counting error was about 0.7%. The effects of inhomogeneity of neutron flux during irradiation were found in the higher sample standard deviations resulting from the runs using large vials. Rotation of packets during irradiation should eliminate this problem. It was concluded that by use of precision-made envelopes and a sample holder allowing reproducible positioning of the envelopes, the total error should be reducible to that inherent in the counting of random events. For common rock types (wt % $Na_2O$ > 1%), counting times of 5 to 10 min per sample should, ideally, result in standard deviations approaching 0.3 to 0.6%. The precision and accuracy are comparable to the best soft x-ray and flame photometric results. (BBB)

**17372** APPLICATIONS OF ACTIVATION ANALYSIS TO REFRACTORY MATERIALS. Laverlochere, J. (CEA, Grenoble, France). Bull. Soc. Fr. Ceram., No. 78, 31-2(Jan.-Mar. 1968). (In French).

Application of activation analysis to the determination of Na, Cl, Mn, and Al in refractory metals or materials is frequent. The most common method is γ spectrometry, because of its selectivity and because of the advantages of decay analysis and coincidence in improving selectivity. Analysis of O is well known because of its short period and because it serves as a ready example of activation by a transportable neutron generator, applicable in factories and in diverse laboratories. A limitation arises from background or matrix activity, or impurities. In such cases chemical separation after irradiation may be used to isolate activity due to impurities. The sensitivity of the method makes it applicable to the analysis of ultrapure samples or to the analysis of very small samples. The method is independent of the form of the sample and applicable to analysis of many forms of an element. (BBB)

**17373** DETERMINATION OF $^{53}$Mn, WHICH WAS PRODUCED IN METEORITIC MATERIAL BY COSMIC RADIATION, WITH THE HELP OF NEUTRON ACTIVATION. Herr, W.; Herpers, U.; Woelfle, R. (Univ., Cologne. Kernforschungsanlage, Juelich, Ger.). J. Radioanal. Chem., 2: 197-203(Mar. 1969). (In German).

Among a number of stable and unstable nuclides formed in material exposed to cosmic radiation the spallation nuclide $^{53}$Mn (T = $2 \times 10^6$ α) was investigated in meteoritic manganese by combined techniques of neutron activation and advanced γ-spectrometry. Intense neutron bombardment transforms the long-lived K-emitter $^{53}$Mn into $^{54}$Mn, which is detected by its 0.84-MeV γ rays. Using the (n,γ) cross section $^{53}$Mn-values in the range of 60 to 600 dpm/kg ($10^{-11}$ g/g) are found in a larger number of iron meteorite samples, which are only 1 to 3 in weight. The determination is very specific and under appropriate conditions unaffected by side reactions. The attempt to use the $^{44}$Ti(n,γ)$^{45}$Ti reactions for the analysis of spallogenic titanium failed, because the $\sigma_{therm}$ of $^{44}$Ti was found to be unexpectedly low (10 barns). Additionally, $^{45}$Sc was determined after (n,γ) reaction by the $^{46}$Sc γ-γ cascades. (auth)

**17374** APPLICATION OF NEUTRON RADIOACTIVATION ANALYSIS AND ELECTRONIC CALCULATION TO THE NON-DESTRUCTIVE DETERMINATION OF CHLORINE TRACES IN SILICA–ALUMINA. Bussiere, P.; Laurent, A.; Junod, E. (CNRS, Rhone, France. CEA, Grenoble, France). J. Radioanal. Chem., 2: 211-17(Mar. 1969). (In French).

A method applicable for serial determination of traces of chlorine in $SiO_2$–$Al_2O_3$ catalysts by neutron activation is described. The results are evaluated by means of a computer. The $^{38}$Cl activity is subtracted from the activity of the interfering components ($^{56}$Mn, $^{24}$Na) and this enables a direct γ-spectrometric determination. In practice ten samples should be irradiated simultaneously and for this reason 3 standards are irradiated together with the samples to correct for the flux gradient. The reproducibility of the method is better than 2% for 10 to 300 mg samples with a Cl content of 10 ppM. (auth)

**17375** NON-DESTRUCTIVE NEUTRON ACTIVATION ANALYSIS OF GOLD AND URANIUM IN RESIDUE SAMPLES OF DIFFERENT ORE BODIES. de Lange, P. W.; Venter, J. H.; de Wet, W. J. (Atomic Energy Board, Pretoria). J. Radioanal. Chem., 2: 219-28(Mar. 1969).

The homogenization of samples of gold ore by methanol mixing was examined by neutron activation in the Safari-1 nuclear reactor. Activity ratios of $^{198}$Au to $^{239}$Np (for gold to uranium contents) and $^{76}$As to $^{239}$Np (for arsenic to uranium contents) were analyzed to study the homogeneity of the samples. In these post-cyanide residue samples, residual gold was found to be considerably less homogeneously distributed than in chemically untreated ore samples. The distribution of uranium in ore samples was not affected by chemical treatment. (auth)

**17376** DETERMINATION OF CHROMIUM IN BLOOD BY NEUTRON ACTIVATION ANALYSIS. Simkova, M.; Krivanek, M. (Nuclear Research Inst., Prague). J. Radioanal. Chem., 2: 229-33(Mar. 1969).

A procedure for the determination of chromium in blood was developed with a sensitivity of $5 \times 10^{-3}$ μg Cr. Dried blood was irradiated with a neutron flux of $10^{12}$ n · cm$^{-2}$ · sec$^{-1}$ in the VVRS reactor for 4 weeks, then the sample was mineralized and the chromium isolated by extraction as perchromic acid. Determination of the chromium content was accomplished by measuring the 0.32-MeV gamma energy of $^{51}$Cr. In order to make correction for the interfering reaction $^{54}$Fe(n,α)$^{51}$Cr, the formation of chromium from high-purity iron was investigated. The chromium content of the blood samples was between $1.03 \times 10^{-2}$ and $5.2 \times 10^{-2}$ ppM Cr. (auth)

**17377** APPLICATION OF NON-ISOTOPE ADDITION TECHNIQUE TO THE DETERMINATION OF COPPER WITH PHOTON ACTIVATION. Abe, S. (Yamagata Univ., Yonezawa, Japan). J. Radioanal. Chem., 2: 275-9(Mar. 1969).

The determination of copper by photon activation in the presence of Cd, Ni, and Fe is reported using a nonisotopic addition technique. Known amounts of zinc are added to the sample and mixed uniformly. The sample is then irradiated with a standard sample. After chemical separation of copper using the copper thiocyanate method the induced activities of 12.8 hr $^{64}$Cu[$^{65}$Cu(γ,n)$^{64}$Cu] and 58.5 hr $^{67}$Cu[$^{68}$Zn(γ,p)$^{67}$Cu] are measured. The analysis is advantageous in that no quantitative recovery of copper is required during separation and the chemical yield of copper need not be determined. (D.H.M.)

**17378** DETERMINATION OF SUBMICROAMOUNTS OF COPPER IN HIGH-PURITY METALS AND METEORITES BY A HIGHLY SELECTIVE γ-γ COINCIDENCE METHOD. Woelfle, R.; Herpers, U.; Herr, W. (Univ., Cologne. Kernforschungsanlage, Juelich, Ger.). J. Radioanal. Chem., 2: 171-82(Mar. 1969). (In German).

Copper was determined nondestructively by neutron activation analysis in the high-purity metals Be, Bi, Pb, Se, Sn, Tl, and in iron meteorite specimens down to concentrations of 40 ppB, while the minimum detectable mass for 1 g-samples as defined recently by Currie was about 0.1 ppB Cu. γ-γ coincidence counting of the annihilation radiation of $^{64}$Cu essentially improved suppression of interferences by other γ-cascade emitters. The latter was achieved by increasing the detector distances and by counting in centric and eccentric positions with respect to the detectors. Using the 180-angle correlation of the annihilation γ-quants of $^{64}$Cu etc. an increase in selectivity (in relation to conventional coincidence methods) was achieved by a factor of about $10^3$. A goniometer arrangement proved to be very advantageous. (auth)

**17379** RADIOACTIVATION AND TRACER STUDIES ON CEMENTS USED IN PETROLEUM PRODUCTION OPERATIONS. Alian, A.; Hallaba, E.; Etman, M.; Bashat, H. (Atomic Energy Establishment, Cairo). Microchem. J., 13: 690-8(Dec. 1968).

Two types of Egyptian cements, seawater and slag, were examined for elements inducing long-lived gamma radioactivity on reactor irradiation. A radiochemical separation procedure was developed for cement samples with high iron content. Activation analysis was used for quantitative determination of trace elements. Cement tagged with irradiated $Sc_2O_3$, ZnO, or sea water cement is recommended for investigations on oil wells. (J.G.B.)

**17380** RECENT EXAMPLES OF NEUTRON ACTIVATION ANALYSIS IN METALLURGY, ELECTRONICS, AND CHEMISTRY. Laverlochere, J. (Centre d'Etudes Nucleaires, Grenoble, France). Method. Phys. Anal., 195-9(Oct.-Dec. 1967). (In French).

When activation analysis is used for nondestructive applications, the specificity is increased by using techniques such as selective irradiation, activity measurement by gamma spectrometry, coincidence techniques, and decay measurements. Examples of recent applications studied in the Nuclear Center of Grenoble given to

illustrate the use of these techniques are the determination of Ca in beryllium, O in many materials, Sc, Co, and Sb in silicon, V in petroleum products, Mn, Fe, U, Co, Cr, Yb, and V in synthetic rubies, and major constituents in cement. These techniques can be used for determining either trace elements or major constituents. Several of them allow rapid and routine determinations, for example, the determination of trace amounts of Au, Sb, and Br. (auth)

**17381** NEUTRON ACTIVATION ANALYSIS AND ITS APPLICATION TO THE ANALYSIS OF FOOD PRODUCTS. Guinn, Vincent P. (Gulf General Atomic Inc., San Diego, Calif.). J. Amer. Oil Chem. Soc., 45: 767-74(Nov. 1968).

Principles and practical aspects of food analysis by use of high-flux thermal-neutron activation analysis are presented. The high sensitivity of the method enables the analysis of food products, for example, for numerous trace-level elements that may be present whether natural or added beneficial essential trace elements, or deleterious elements introduced from pesticide residues (such as Br, As, and Hg), or from processing (such as Cr, Sn, Sb, and Cu). Studies reported include the nondestructive determination of Hg in foodstuffs down to levels as low as 0.01 ppM, and Br down to about 0.1 ppM. With radiochemical separations, these detection limits can both be extended to 0.001 ppM, if needed. By combination with paper chromatographic or solvent extraction techniques, phosphorus- and halogen-containing pesticides can be sensitively determined. The method can also be used to advantage at element levels much higher than trace levels, and in such cases the very high neutron flux of a nuclear reactor may not be necessary. For example, even with a small 14-MeV neutron generator, the nitrogen content of foodstuffs can be determined nondestructively, rapidly, and accurately, down to levels of about 100 ppM. These determinations can also be made on-line in food processing plants. (BBB)

**17382** IODINE ACTIVATION ANALYSIS IN MATERIALS OF BIOLOGICAL INTEREST. Malvano, R.; Grosso, P. (SORIN Centro Ricerche Nucleari, Saluggia, Italy). J. Nucl. Biol. Med., 12: 86-97(Apr.-June 1968).

Neutron-activation methods developed and employed for trace-iodine analysis in biological research are described and discussed (determination in water, homogenized food, excreta, and biological tissues). The analytical precision and accuracy are evaluated, and a comparison with chemical methods made. Some miscellaneous results are reported. (auth)

**17383** DETERMINATION OF RARE EARTH ELEMENTS IN HOT SPRING WATER BY RADIOACTIVATION METHOD. Oda, Toshiyuki (Kyushu Univ., Japan). Radioisotopes (Tokyo), 18: 39-43(Feb. 1969). (In Japanese).

A radioactivation method for the determination of rare earth elements in hot spring water was studied and the concentrations of those elements in 5 Beppu hot springs, Wairakei (New Zealand), and sea water were determined. The rare earth elements were precipitated on calcium oxalate from 10 l spring water, ignited, and then irradiated by KUR (neutron flux $4 \times 10^{12}$ n/cm$^2$ · sec). After irradiation, the rare earth elements were separated radiochemically, and the radioactivities were measured with a 512 channel pulse-height analyzer. The concentrations of Sc, La, Sm, Eu, and Dy in the waters were 5.3 to 0.05 μg/l, 0.8 to 0.02 μg/l, 0.34 to 0.01 μg/l, 0.04 to 0.001 μg/l, and 0.5 to 0.02 μg/l, respectively. The concentration of La in Beppu hot spring waters was considerably lower than that in Wairakei's. (NSA of Japan)

**17384** SIMULTANEOUS DETERMINATION OF STRONTIUM AND BARIUM BY NEUTRON ACTIVATION ANALYSIS WITH A Ge(Li) DETECTOR. Higuchi, Hideo (Rikkyo Univ., Yokosuka, Japan); Tomura, Kenji; Takahashi, Hiroshi; Onuma, Naoki; Hamaguchi, Hiroshi. Anal. Chim. Acta, 44: 431-7(Feb. 1969).

A method is described for the simultaneous determinations of strontium and barium in rock samples by neutron activation analysis with a Ge(Li) detector after chemical group separation. The re-activation technique was employed to obtain the chemical yields for both elements without any additional chemical treatment. The values obtained for several geochemical standard rocks (G-1, W-1, G-2, GSP-1, AGV-1, and BCR-1) are in reasonable agreement with previously published data. (auth)

**17385** RADIOACTIVATION ANALYSIS OF THE INORGANIC IONS OF SEVERAL TEXTILE FIBERS. Nascutiu, T.; Pencea, C. (Inst. for Atomic Physics, Bucharest). Rev. Roum. Chim., 13: 1359-63(Oct. 1968).

Inorganic ions in teron, relon, melana, and polypropylene synthetic fibers were determined by thermal neutron activation. Both nondestructive and destructive analyses were carried out. In the latter case paper chromatography was used for chemical separation. The impurities determined were Sb, Na, Cl, Ag, Ti, Rb, and Mn. (P.C.H.)

# Inorganic, Organic, and Physical Chemistry

*Refer also to abstracts 17464, 17508, 17511, and 17528.*

**17386** (AAEC/TM-476) THE PREPARATION AND CALCINATION OF AMMONIUM URANATES: A LITERATURE SURVEY. Woolfrey, J. L. (Australian Atomic Energy Commission Research Establishment, Lucas Heights). Sept. 1968. 38p. Dep.

The preparation and calcination of ammonium uranates is reviewed. Topics covered include the preparation of ammonium uranates by precipitation or solid state reaction; the effects of preparation conditions upon the composition, structure, morphology, surface area, and filtration of ammonium uranates; the thermal decomposition and reduction of ammonium uranates; and the effects of calcination conditions on the physical properties of the resultant powder. (58 references). (auth)

**17387** (AEC-tr-7028, pp 199-208) SECR: FORMATION OF A THIRD PHASE IN TRILAURYLAMINE SOLUTIONS. (Commissariat a l'Energie Atomique, Fontenay-Aux-Roses (France). Centre d'Etudes Nucleaires). Translated from pp 393-401 of report CEA-N-969.

Organic solutions were studied near the appearance of the third phase by conventional methods of colloid chemistry to determine the relation between the micellar coagulation of alkylamine salts and demixing of their solutions. It was found that demixing is preceded by a significant growth of micelles. (M.C.G.)

**17388** (ANL-7472) VIOLENTLY SPRAYED SODIUM-AIR REACTION IN AN ENCLOSED VOLUME. Krolikowski, Theresa S. (Argonne National Lab., Ill.). Sept. 1968. Contract W-31-109-eng-38. 65p. Dep. CFSTI.

Ten-gram quantities of molten sodium (350 to 425°C) were injected by a pneumatic, piston spray-injector with drive pressures of 1000 to 1500 psig into a closed reaction chamber, 91.44 cm high and 15.24 cm in diameter, containing dry air or dry air-nitrogen mixtures. The sodium was sprayed through seven 0.0762- or 0.0254-cm-diam orifices. The rate of the pressure rise resulting from the sodium-air burning reaction was measured during the spraying interval. The pressure-rise was a measure of the reaction rate. The pressure-rise rates ranged from 25 to 75 atm/sec, and the peak pressures attained were in the range 1.6 to 4.1 atm. The experimental results were compared on a reduced pressure-rise rate basis, (atm/sec)/(g Na/cm$^3$). The pseudoconcentration term, g Na/cm$^3$, was the weight of the in-flight burning sodium in the spray at any time after the spray reached the top of the chamber, divided by the volume of the chamber. This conversion eliminated the restrictions of the spray-chamber geometry and the sodium mass flowrate. The spray particle size had the most pronounced effect on the reaction rate, which increased as the particle size decreased. Increasing the spray velocity resulted in a modest increase in the reaction rate. The reaction rate decreased slowly as the oxygen content of the atmosphere was lowered until, at an oxygen concentration of 4 mole %, there was no visible burning. A mathematical model was developed to predict the burning rate and burning temperature of a single spherical sodium particle moving through air or air depleted in oxygen. The model was based on the assumption that the reaction rate was controlled by the diffusion of oxygen to a combustion zone surrounding the particle. A quasi-steady-state approach and an averaging technique were used to correlate the reaction rates of individual particles with the theoretical burning rate of a spray and the theoretical pressure rise in the enclosing volume. The theory correctly predicted the direction and magnitude of the experimentally observed variations in reaction rate with respect to oxygen content, spray velocity, and particle size. The theory also predicted a cessation of vapor-phase combustion below an oxygen concentration of 4 mole %. (auth)

**17389** (ANL-Trans-703, pp 1-8) ELECTROCHEMISTRY STUDIES. (Commissariat a l'Energie Atomique, Fontenay-Aux-Roses (France). Centre d'Etudes Nucleaires). Translated from Section 4 of report CEA-N-969.

Research is reported on $UO_2$ production by igneous electrolysis, electrode interfaces, nickel deposition at high temperature under pressure, deposits of nickel–chromium alloys, deposition of gold on copper–nickel alloy, air corrosion of nickelized uranium reglets, and corrosion of steel faced with different deposits of chromium and nickel in water at 80°C. (M.C.G.)

**17390** (BM-RI-7246) PHASE DIAGRAM FOR THE KF-$YF_3$ SYSTEM. Porter, Bernard; Meaker, R. E.; Bremner, P. R. (Bureau of Mines, Reno, Nev. Reno Metallurgy Research Center). Mar. 1969. 8p.

Differential thermal analysis measurements were used to

characterize a phase diagram for the $KF-YF_3$ system at compositions between 0 and 60 mole % $YF_3$. A congruent melting point compound was observed at $3KF \cdot YF_3$, which melts at 965 ± 5°C and undergoes solid-state decomposition at 725 ± 2°C. One peritectic and two eutectic compositions are also defined. (auth)

**17391** (CEA-R-3521) SPECTROPHOTOMETRIC STUDY OF THE COMPLEXES OF CERIUM AND URANIDES WITH DIETHYLENETRIAMINEPENTAACETIC ACID (DTPA). Hafez, Mohamed Badreldin (Commissariat a l'Energie Atomique, Fontenay-aux-Roses (France). Centre d'Etudes Nucleaires). June 1968. 140p. (In French). Dep.

A spectrophotometric determination was made of the complexes of cerium and uranides (uranium, neptunium, plutonium, and americium) in their different degrees of oxidation with diethylenetriaminepentaacetic acid (DTPA). Two physicochemical states, the ionic and hydrolysis ones, were considered. In the former case, the influence of the pH on the formation of the complex was studied, and whenever the complexes were stable, the molecular ratio was determined and their stability constants were calculated. In the latter case, the conditions of solubilization of the precipitation were studied by formation of complexes soluble in water as a function of pH, age of the precipitate, and time of precipitate-chelate contact. (auth)

**17392** (CEA-R-3656) CONTRIBUTION TO THE STUDY OF U-Ti AND U-Pu-Ti CARBIDES. Milet, Claude Andre (Commissariat a l'Energie Atomique, Fontenay-aux-Roses (France). Centre d'Etudes Nucleaires). Dec. 1968. 77p. (In French). Dep.

Thesis. Submitted to Univ., Poitiers, France.

Reasons for using (U, Pu) carbides as fast reactor fuel and the influence of additions of titanium to these carbides are considered. A preliminary study was made on the system U-C-Ti and some properties were measured such as: density, thermal expansion, electrical resistivity, atmospheric corrosion, and compatibility with stainless steel. The systems U-Pu-C-Ti (Pu/U + Pu equal to 15 per cent) and U-C-Ti were found to be very similar. There exists a two-phase region (U,Pu)C + TiC and an eutectic between (U,Pu)C and TiC for approximately 15 at. %. The solubilities of U + Pu in TiC and of Ti in (U,Pu)C were less than 1 at. %. The addition of titanium did not markedly change thermal expansion coefficients of (U,Pu)C. However the resistance to atmospheric corrosion and compatibility with stainless steel was improved. Thermal conductivity, calculated from electrical resistivity, increased. The density of the fissile material was lowered. The combination of (U,Pu)C + TiC seems to be the most promising alloy for application as nuclear fuel. (auth)

**17393** (IS-1987) ABSORPTION SPECTRUM AND ZEEMAN EFFECT OF DYSPROSIUM ETHYLSULFATE. Haas, W. J. Jr.; Spedding, F. H. (Ames Lab., Iowa). May 1968. Contract W-7405-eng-82. 272p. Dep. CFSTI.

The energies and/or intensities of many absorption lines in the HsC Zeeman patterns of single crystals of dysprosium ethyl sulfate (DyES) have been found to have 60° periodic anisotropy with respect to the angle $\phi_m$ between the x axis of the crystal and the direction of the external magnetic field. The magnetic field was applied in the basal plane and the light was shone in perpendicular to both the c axis and the magnetic field. The spectra were observed as a function of orientation of the crystal about the c axis. The energy of every line, if it had a measurable variation, reached its maximum or minimum at a common angle, but the intensities of the lines attained their maximum or minimum values at various angles. The observations were in agreement with recent works on the theory of the Zeeman effect for rare earth ions in crystal fields with $C_{3h}$ symmetry. Detailed measurements of the energy variations of the absorption lines of groups G and I of DyES in an external magnetic field of 28 kG showed that most of the energy variations resulted from changes in the energies of the low lying HsC Zeeman levels of the ground term. The anisotropic HsC Zeeman effect of DyES was observed for the first time in this work, and DyES is the first of the rare earth ethyl sulfates for which this effect has been shown to be important for the levels of the ground term. The $C_{3h}$ point symmetry at the rare earth ion site imposes the requirement that the energy of every absorption line, if it varies at all, must reach its maximum or minimum when the magnetic field is parallel to an x axis of the crystal. This fact was used in attempts to determine the angle $\phi$ between the x axis and the a translation axis of single crystals of DyES, $(DyES)_{10}(YES)_{90}$, and $(DyES)_v(ErES)_{100-v}$ with v equal to 10, 50, and 90. The average value of $\phi$ for both $Er^{+3}$ and $Dy^{+3}$ in all the samples studied was 6.5 ± 1.4°. The parallel and perpendicular Zeeman effects of line groups G through M (22000 to 28000 $cm^{-1}$) were also studied as a function of external magnetic field, up to 28 kG, and field dependent energy level schemes were derived for the low lying levels of the ground term and for the excited levels of all but group K. (P.C.H.)

**17394** (JAERI-5018, pp 70) ION RADICALS OF STYRENE IN IRRADIATED ORGANIC GLASSES STUDIED BY ELECTRON SPIN RESONANCE. Iwamoto, Takeo; Hayashi, Koichiro; Okamura, Seizo; Hayashi, Kanae; Yoshida, Hiroshi (Japan Atomic Energy Research Inst., Osaka. Osaka Lab.). (In English and Japanese).

In order to study the correlation between active species formed from styrene by radiation and its radioinduced polymerization, irradiated organic glasses containing styrene were examined by electron spin resonance at 77°K. In 2-methyltetrahydrofuran glass, anion radicals of styrene were formed by the transfer of electrons ejected by radiation from the glass matrix molecules to styrene. In n-butylcholoride glass, cation radicals of styrene were formed by the transfer of positive charges. The electron spin resonance spectrum of the anion radicals is a broad singlet with the width between the maximum slope points of 15 Gauss and bleached readily by visible lights, whereas that of the cation radicals has a width of 23 Gauss and is not bleached. The radioinduced polymerization proceeded in the glass only when the cation radicals were present. This suggests that the radioinduced polymerizatior of styrene, especially in the glassy state, proceeds by cationic mechanism. (auth)

**17395** (LA-4078) THE SOLUBILITIES OF SELECTED ELEMENTS IN LIQUID PLUTONIUM. XIV. NIOBIUM IN GALLIUM-PLUTONIUM ALLOYS. Bowersox, D. F. (Los Alamos Scientific Lab., N. Mex.). Jan. 8, 1969. Contract W-7405-eng-36. 6p. Dep. CFSTI.

The solubility of niobium in gallium-plutonium alloys containing 0 to 10 at. % gallium was measured over the temperature range 700 to 1000°C. The solubility decreased as the gallium concentration increased. For example, at 850°C the solubility decreased from 2.05 at. % niobium in liquid plutonium to 1.75 at. % niobium in 9.6 at. % gallium alloy. The solubility data fit the equation: $\log \delta_{Nb}^{Pu+Ga} = N_{Pu} \log \delta_{Nb}^{Pu} + N_{Ga} \log \delta_{Nb}^{Ga}$, where the δ's are the activity coefficients of niobium in the alloy (Pu + Ga), in liquid plutonium, and in liquid gallium, and $N_{Pu}$ and $N_{Ga}$ are the atomic fractions of plutonium and gallium in the alloy of interest. (auth)

**17396** (NP-tr-1733) DETERMINATION OF THE WATER-HYDROGEN SELENIDE ISOTOPIC EQUILIBRIUM CONSTANT. Marx, D. Translated by C. R. Brightmore for Atomic Energy Research Establishment, Harwell, Eng., from Compt. Rend. 247: 2340-2(1958). 4p. Dep.

An abstract of this paper, prepared from the original language, appeared as NSA 13: 7519.

**17397** (ORNL-4358) $^{90}Sr$ DATA SHEETS. Rimshaw, S. J.; Ketchen, E. E. (Oak Ridge National Lab., Tenn.). Mar. 1969. Contract W-7405-eng-26. 49p. Dep. CFSTI.

Data are given for composition and various properties of $^{90}Sr$ metal, strontium titanate, strontium oxide, strontium fluoride, and strontium orthotitanate. The information presented includes: composition, specific power, radiation, critical mass, compatibility with materials of containment, thermophysical properties, mechanical properties, chemical properties, biological tolerances, and shielding data. (P.C.H.)

**17398** (ORNL-4378) INFRARED STUDIES OF THORIUM OXIDE SURFACES. Fuller, E. L. Jr.; Holmes, H. F.; Gammage, R. B. (Oak Ridge National Lab., Tenn.). Mar. 1969. Contract W-7405-eng-26. 61p. Dep. CFSTI.

Infrared analytical techniques were used to study the surface of thorium oxide. Adsorbed water was shown to exist in four distinct forms. Above 300°C the free hydroxyl stretching frequency exists as 3742 $cm^{-1}$. There also exist three distinct hydrogen bonded species characterized by bands at 3665, 3550, and 3310 $cm^{-1}$. The concentration of all of these species varies with the temperature of the sample, which dictates the amount of sorbed species present. The tenacity of water retention is noted by virtue of the high temperatures required for its removal in vacuum. The merit of observing the spectra at elevated temperatures is noted, relative to the practice of obtaining room temperature spectra as indicative of phenomena occurring at previously elevated temperatures. $D_2O$ exchange studies at various temperatures further show the tenacity of water binding and substantiates the frequency assignment. The frequencies of absorption bands in the region of 200 to 2000 $cm^{-1}$ is strongly dependent on the mode of preparation and seem to be related to the predominating crystal habit. The intensities of the characteristic frequencies are nearly independent of temperature and pressure for a given preparation. Calcination in air decreases the intensities as the surface area decreases but does not shift the bands. These vibrational bands all seem to be the result of a single phenomena over the entire 200 to 2000 $cm^{-1}$ range and seem to be a result of surface and/or finite crystal modes of the thorium oxide. Comparisons are made to the spectroscopic analyses of

others and tentative explanations are given. Unanswered questions are posed and further avenues of investigation are proposed. (auth)

**17399** VIBRONIC INTENSITY DISTRIBUTION IN THE PHOSPHORESCENCE OF BENZENE AND ITS DEUTERATED ISOMERS. Nieman, G. C. (Univ. of Rochester, N. Y.). J. Chem. Phys., 50: 1660-73(Feb. 15, 1969).

The ground-state vibrational frequencies and the relative vibronic intensities of the phosphorescence were calculated for all and measured for one carbon-13 and ten of the possible twelve deuterium-substituted benzenes. The intensities were calculated within the framework of the Herzberg–Teller model. It was found that the relative intensities for different vibronic transitions of isotopically related molecules can be expressed in terms of two factors; a normal coordinate eigenvector matrix element which is isotope dependent, and an electronic term which is isotope independent. The observed $C_6H_6$ intensities are used to evaluate the electronic parameters. Excellent agreement is found among the calculated and observed intensities and frequencies. The relative importance of the different coordinates for vibronic coupling in benzene is indicated. (auth)

**17400** STUDY OF ANTIFERROMAGNETISM IN $Mn(DCOO)_2$, $2D_2O$ BY NEUTRON DIFFRACTION. Bertaut, Erwin F.; Burlet, Paulette; Burlet, Paul (CNRS, Grenoble, France). Solid State Commun., 7: 343-9(1969). (In French).

In $Mn(DCOO)_2$, $2D_2O$, isomorphous with $Mn(HCOO)_2$, $2H_2O$, the spins of Mn in 000 and $0\frac{1}{2}\frac{1}{2}$ are ordered antiferromagnetically at $T_N = 3.7°K$ along the binary axis b. At $T_0 = 1.7°K$ the spins rotate and were found to be in the ac plane, making an angle $\phi = 63° \pm 5°$ with the a axis. The transition at 1.7°K is an anisotropy transition belonging to the first order. The anisotropy is not of dipolar origin. The spins of the Mn atoms in $\frac{1}{2}0\frac{1}{2}$ and $\frac{1}{2}\frac{1}{2}0$ are still paramagnetic. (auth) (UK)

**17401** POTENTIALS FOR THE HYDROGEN ATOMS IN NORMAL AND DEUTERATED $KH_2PO_4$. Sato, Yoshiki (Japan Atomic Energy Research Inst., Tokai); Machida, Yoshihiro. Solid State Commun., 7: 327-9(Feb. 1969).

Infrared spectra were measured on normal and deuterated $KH_2PO_4$ in the regions 500 and 1000 $cm^{-1}$ at various temperatures. The spectra revealed a marked change as the temperature passed through the Curie point 123°K. In contrast, the spectra of $KD_2PO_4$ exhibited no appreciable change above and below the Curie point 213°K. From these facts it is concluded that above the Curie point each H atom moves in a potential with a flattened-bottom in $KH_2PO_4$ and each D atom moves in a symmetrical double minimum potential in $KD_2PO_4$. (auth) (UK)

**17402** IR INTENSITIES IN $CHCl_3$ AND $CDCl_3$. Morcillo, J.; Biarge, J. F.; Heredia, J. M. V.; Medina, A. (CSIC, Madrid. Univ., Madrid). J. Mol. Struct., 3: 77-87(Jan.-Feb. 1969).

The integrated intensities of the fundamental ir absorption bands of $CHCl_3$ and $CDCl_3$ were measured using the pressure-broadening technique. These intensities are interpreted in terms of displacement polar tensors, which give the change of the dipole moment of the molecule due to a set of displacements of their atomic nuclei. The components of these polar tensors for the nuclei of both molecules were calculated for all the possible combinations of the signs of the dipole moment derivatives with respect to the normal coordinates. By comparing the results for both molecules and for $CHF_3$ and $SiHCl_3$, the most satisfactory choice of signs was decided. Calculations of integrated intensities from recorded spectra and of displacement polar tensors from these intensities, were carried out in a 7070-IBM computer. (auth)

**17403** CORRECTION TO THE EFFECT OF ANHARMONICITY ON ISOTOPIC EXCHANGE EQUILIBRIA: APPLICATION TO POLYATOMIC MOLECULES. Wolfsberg, Max (Brookhaven National Lab., Upton, N. Y. State Univ. of New York, Stony Brook). J. Chem. Phys., 50: 1484-6(Feb. 1, 1969).

This note points out that the measured equilibrium constant $K_1$ for the reaction of $H_2O_{(g)} + D_2O_{(g)} \rightleftharpoons 2HDO_{(g)}$ is about 10% larger than the value calculated from spectroscopic data by usual statistical methods and that this disagreement originates largely from neglect of a term $G_0$, which is dependent on isotopic substitution. $K_2$, the equilibrium constant for $H_2O_{(g)} + HD_{(g)} \rightleftharpoons H_{2(g)} + HDO_{(g)}$, is also discussed. (B.L.M.)

**17404** REVISED ZERO-POINT ENERGY CALCULATION FOR $H_2O + D_2O \rightleftharpoons 2HDO$ ISOTOPIC EQUILIBRIUM. Hulston, J. R. (Inst. of Nuclear Sciences, Lower Hutt, New Zealand). J. Chem. Phys., 50: 1483-4(Feb. 1, 1969).

The failures of the conventional anharmonic calculation methods for the calculation of the equilibrium constant $K_1$ at 25°C for the reaction $H_2O + D_2O \rightleftharpoons 2HDO$ are discussed. The term $G_0$, which arises in the equilibrium calculations as a result of rotational-vibrational coupling was evaluated for $H_2O$, $D_2O$, and HDO using experimental anharmonicities of published work. The contributions of each equation in the calculation of $G_0$ are tabulated, and a revised anharmonic value of $K_1$ at 25°C is compared with values calculated by the method described using experimental values of previously published workers at 0°, 25°, and 75°C. The $K_1$ values thus obtained fall very close to the experimental values. (B.L.M.)

**17405** PHYSICO-CHEMICAL STUDIES OF AMMONIUM URANATES. Nguyen Quy-Dao (Ecole Normale Superieure, Paris). Bull. Soc. Chim. Fr., No. 12, 4751-9(Dec. 1968). (In French).

The formation of ammonium uranates has been studied by various methods, such as potentiometry, conductometry, infrared spectroscopy, and chemical analysis. When ammonium hydroxide is poured into a solution of uranyl nitrate, various uranates with different compositions are formed in the first stage. However, from a precipitation procedure (rapid and in diluted solutions), the occurence of a hexacondensed ion $U_6O_{16}(OH)_2^{2+}$ can be observed, which then gives a uranate. With a large excess of ammonium hydroxide, a second uranate with a different formula is obtained. Uranyl hydroxide has not been obtained. (auth)

**17406** PREPARATION AND PROPERTIES OF URANIUM FORMATES. Bressat, Rene; Claudel, Bernard; Navarro, Alain (Institut National des Sciences Appliquees, Lyon). Bull. Soc. Chim. Fr., No. 12, 4807-11(Dec. 1968). (In French).

Methods for the preparation of uranyl formates are described. The anhydrous salt is characterized by its x-ray diffraction pattern. The best conditions for electrochemical reduction of uranyl formate were studied. Several formates corresponding to stage IV oxidation of uranium were isolated and characterized. Among them, $U(HCOO)_4$ occurs in at least two allotropic forms for which the x-ray diffraction diagrams are given for the first time. (auth)

**17407** COMPARATIVE STUDY OF THE HYDROLYSIS OF EUROPIUM AND AMERICIUM IN CHLORIDE MEDIUM BY ELECTROPHORESIS ON PAPER. Marin, Bernard; Kikindai, Tivadar (Ecole Centrale des Arts et Manufactures, Paris. CEN, Fontenay-aux-Roses, France). Compt. Rend., Ser. C, 268: 1-4(Jan. 6, 1969). (In French).

Electrophoresis on a support permits the measurement of the mobility of a particle subjected to the action of an electric field. This method has made it possible to study the hydrolysis of americium and europium in a chloride medium (HCl–KCl) with an ionic strength of $5 \times 10^{-3}$M. It was observed that americium hydrolyzes at a pH more acid than europium. It was possible to assign a value to the first hydrolysis constant of the two cations $K_1 = (2.0 \pm 0.2) \times 10^{11}$ for americium and $K_1 = (1.6 \pm 0.2) \times 10^{11}$ for europium. (tr-auth)

**17408** PREPARATION OF ALLENIC DIETHERS AND THEIR TRANSFORMATION INTO $\alpha$-ETHYLENIC-$\alpha$-DEUTERATED-4-ALKOXYALDEHYDES. Mantione, Richard; Alves, Avany (CNRS, Paris). Compt. Rend., Ser. C, 268: 365-8(Jan. 27, 1969). (In French).

Acetylenic $\alpha,\alpha'$-diethers were isomerized into allenic diethers by potassium tert-isobutylate in dimethyl sulfoxide. The allenic compounds formed were hydrolyzed by a deuterated acid in solution in heavy water into $\alpha$-ethylenic-$\alpha$-deuterated alkoxyaldehydes. These latter compounds were compared with their undeuterated homologs. (tr-auth)

**17409** A NEW COMPOUND: UNF. Yoshihara, K.; Kanno, M.; Mukaibo, T. (Tokyo Univ.). J. Inorg. Nucl. Chem., 31: 985-8(Apr. 1969).

The new compound UNF was prepared by the reaction of $UF_4$ with silicon and nitrogen. The crystal structure of UNF was determined to be tetragonal, with dimensions $a = 5.612 \pm 0.001$ Å, $b = 5.712 \pm 0.001$ Å. This compound is converted to $U_2N_3$ in nitrogen atmosphere, and converted to UN in argon atmosphere at elevated temperatures. The compound is not stable in air even at room temperature due to oxidation. (auth) (UK)

**17410** KINETICS AND ISOTOPE EFFECT OF AMMONIA SYNTHESIS OVER AN UNPROMOTED IRON CATALYST. Aika, Ken-ichi; Ozaki, Atsumu (Tokyo Inst. of Tech.). J. Catal., 13: 232-7(Feb. 1969).

The kinetics and deuterium isotope effect of the ammonia synthesis reaction over unpromoted iron catalyst were studied at 305°C. Some runs were carried out with mixtures of hydrogen and deuterium. The kinetic data as well as the isotope effect indicate that the rate-determining step is the chemisorption of nitrogen on a surface mainly covered with nitrogen atoms, and not with NH radicals as previously concluded for the doubly promoted catalyst. This result suggests that a part of the role of potash promoter is the change of the adsorbed species which retards the chemisorption process. (auth)

**17411** SPECTROPHOTOMETRIC STUDIES OF CHELATE FORMATION OF LANTHANUM AND THORIUM WITH PICRAMINE AZO DYES. Goyal, S. S.; Tandon, J. P. (Univ. of Rajasthan, Jaipur, India). Aust. J. Chem., 21: 2433-6(Oct. 1968).

Picramine azo dyes have been employed as spectrophotometric reagents, as well as 0,0′-dihydroxypicramine azo dyes, as they give sharp color changes with Th and rare earths in the pH ranges 1.5 to 4.0 and 6.0 to 9.0, respectively, and can be used for their complexometric titrations. Detailed spectrophotometric studies of the chelates of Th and La were made with two representative dyes, Picramine CA and Picramine R. The azo dyes formed water-soluble yellowish pink complexes with Th and La in the pH ranges 1.5 to 4 and 6 to 9, respectively. The compositions of the complexes determined by continuous variations and molar ratio methods were found to be 1:2 in Th-Picramine CA and 1:1 in La-Picramine R systems. The order of the formation constant of Th-Picramine CA complex is $10^{11}$ and that of La-Picramine R is $10^5$. The free energy changes of formation were also calculated. (BBB)

**17412** URANIUM AMALGAM FROM AQUEOUS SOLUTION. Kobayashi, Yoshii; Ishimori, Tomitaro (Japan Atomic Energy Research Inst., Tokyo). J. Inorg. Nucl. Chem., 31: 981-4(Apr. 1969).

It was found that reduction of uranyl acetate with sodium amalgam results in the formation of uranium amalgam. The value obtained for the content of uranium in the amalgam is 0.3 g/100 ml Hg at room temperature. This amount is larger than that previously reported for the solubility of uranium in mercury. (auth) (UK)

**17413** KONTSENTRIROVANIE AKTINOIDOV SOOSAZHDENIEM S ORGANICHESKIMI SOOSADITELYAMI. (Concentration of Actinides by Co-Precipitation with Organic Co-Precipitators). Kuznetsov, V. I.; Akimova, T. G. Moscow, Atomizdat, 1968. 232p.

Information is included on precipitation chemistry, including organic coprecipitates and the method of application of organic coprecipitates, concentration of actinides, including those in aqueous solutions, and methods of actinide concentration with organic coprecipitators, including studies on Pa, U, Np, Pu, Am, and Cm. (438 references). (P.C.H.)

**17414** SOME PHYSICAL PROPERTIES OF SINGLE CRYSTALS OF NORMAL AND DEUTERATED RUBIDIUM DIHYDROGEN ARSENATE. I. PIEZOELECTRIC AND ELASTIC PROPERTIES. Adhav, R. S. (Edo Ltd., Cornwall, Ontario). J. Phys., D (London), 2: 171-6(Feb. 1969).

The elastic and piezoelectric constants of single crystals of rubidium dihydrogen arsenate grown in $H_2O$, and of rubidium dideuterium arsenate grown in $D_2O$, were measured in the temperature range 20 to 80°C. The shear elastic constants $S_{44}$ and $S_{66}$ and the extensional elastic constants $S_{11}$ and $S_{33}$ increased slightly on deuteration, while their temperature coefficients decreased slightly. The piezoelectric constants $d_{14}$ and $d_{36}$ increased by 48 and 61%, respectively, on deuteration at 25°C. For normal RbDA the elastic constants measured at 25°C are: $S_{11} = 22.8 \times 10^{-12}$, $S_{12} = 8.5 \times 10^{-12}$, $S_{13} = -1.8 \times 10^{-12}$, $S_{33} = 25.4 \times 10^{-12}$, $S_{44} = 96.0 \times 10^{-12}$, and $S_{66} = 232.0 \times 10^{-12}$ $m^2$ $N^{-1}$. The piezoelectric constants are $d_{14} = 9.9 \times 10^{-12}$ C $N^{-1}$ and $d_{36} = 28.5 \times 10^{-12}$ C $N^{-1}$. (auth) (UK)

**17415** SOME PHYSICAL PROPERTIES OF SINGLE CRYSTALS OF NORMAL AND DEUTERATED RUBIDIUM DIHYDROGEN ARSENATE. II. ELECTRO-OPTIC AND DIELECTRIC PROPERTIES. Adhav, R. S. (Edo Ltd., Cornwall, Ontario). J. Phys., D (London), 2: 177-82(Feb. 1969).

The electro-optic and dielectric constants of single crystals of rubidium dihydrogen arsenate grown in $H_2O$, and of rubidium dideuterium arsenate grown in $D_2O$ were measured. On deuteration the relative dielectric constant $K_{33}$ was increased from 28.5 to 42.5 and $K_{11}$ was increased from 54.5 to 71.5 at 25°C. The half-wave retardation voltage $V_{\lambda/2}$, measured at 500 nm, was decreased from 3.8 kv to 3 kv, and the electro-optic constant $r_{63}$ was increased from $16.7 \times 10^{-10}$ cm $V^{-1}$ to $21.6 \times 10^{-10}$ cm $V^{-1}$, on deuteration. The loss tangent tan $\delta_{33}$, measured at 1 kHz and at 25°C, was about 2.6 for D-RbDA and 5.2 for RbDA. The specific resistivity $\rho_{33}$ for RbDA was $3.4 \times 10^6$ Ω cm and that for D-RbDA was $3.6 \times 10^7$ Ω cm, measured at 25°C. The input power requirement using these crystals in an electro-optic modulator is compared to that of KDP. (auth) (UK)

**17416** STUDY OF THE DECARBOXYLATION OF THORIUM TETRAFORMATE. Mentzen, Bernard (Institut National des Sciences Appliquees, Lyon). Ann. Chim. (Paris), 3: 367-84 (July-Aug. 1968). (In French).

The pyrolysis of thorium formate gave only $ThO_2$ as a solid. No other solid formation was detected by thermogravimetric analysis, x-ray diffraction, or differential thermal analysis. The kinetics of the decarboxylation process of $Th(HCOO)_4$ obeyed the Prout and Tompkins' law over the temperature range 225° to 280°C, with an activation energy of 36 Kcal $mole^{-1}$. The gases formed from the decarboxylation of $Th(HCOO)_4$ were analyzed by gas chromatography and mass spectroscopy in the temperature range 225° to 411°C. The primary gases of the thermolysis of $Th(HCOO)_4$ were HCHO and $CO_2$. The composition of this gaseous phase was modified in the presence of thoria and the secondary gases evolved were: $H_2$, CO, $H_2O$, $CH_3OH$, $HCOOCH_3$, HCOOH, and $(CH_3)_2O$. Thoria acted simultaneously as a catalyst on the gaseous phase and for the pyrolysis of the solid. It is possible to follow the decarboxylation of thorium formate by metallic nickel arising from the simultaneous decomposition of nickel formate. (BBB)

**17417** ANODIC OXIDATION OF CURIUM. Haissinsky, Moise; Dran, Jean-Claude; Klein, Roger; Pluchet, Elisabeth (Laboratorire Curie, Paris). J. Chim. Phys., 65: 2119-25(Nov.-Dec. 1968). (In French).

Various factors which determine the behavior of the anodic deposit of curium (concentration, acidity, potential, nature of the anion, stirring, etc.) were examined. A study of the role of different reagents showed that they can either provoke the dissolution of the deposit, or on the contrary, act as stabilizers or even increase the deposited amount. It is concluded that the deposit is essentially composed of the dioxide $CmO_2$. (auth)

**17418** POLAROGRAPHY AND ELECTROLYTIC REDUCTION OF HEXAVALENT MOLYBDENUM. Lamache-Duhameaux, Myriam; Cadiot, Michelle; Souchay, Pierre (Faculte des Sciences, Paris). J. Chim. Phys., 65: 1921-36(Nov.-Dec. 1968). (In French).

Polarography of Mo(VI), associated to controlled-potential electrolysis, was studied in detail in acetic, chloracetic, and sulfuric buffers, and in hydrochloric acid medium. Three waves, I, II, and III are generally observed. In all cases, I represents the reduction of Mo(VI) to Mo(V); its height, however, is often lower than 1 Faraday, in consequence of inhibition resulting from adsorption of depolarizer. This phenomenon explains also the division of I into I and I′ in some media (sulfuric chloroacetic). The significance of II and III waves is different according to cases: in acetic buffers, they result respectively from the reduction to Mo(III) of polymolybdate, and acetic complex of Mo(VI) and in sulfuric and hydrochloric media, II also corresponds to the reduction of Mo(VI) to Mo(III) but its height is generally less than 3 Faradays, because of a secondary reaction between Mo(VI) diffusing towards the electrode, and Mo(III) which appears at the electrode; with this reaction there is a production of Mo(V), which is only reduced to Mo(III) at the level of III. In chloracetic buffers, of acidities situated between those of acetic and sulfuric buffers, there is a superposition of the previous phenomena. (auth)

**17419** $^{15}N$ NMR CHEMICAL SHIFTS IN $^{15}ND_3$, $^{15}ND_2H$, $^{15}ND_2H$, $^{15}NDH_2$, AND $^{15}NH_3$. Litchman, William M. (Univ. of New Mexico, Albuquerque); Alei, Mohammed Jr.; Florin, Alan E. J. Chem. Phys., 50: 1897-98(Feb. 15, 1969).

The spectra recorded for two mixtures with over-all H/D ratios of 1/3 (sample I) and 3/1 (sample II) were recorded in the liquid state at room temperature. The observed spectra of sample I contained 26 peaks, easily separable into several well-defined multiplets. The largest peaks were the seven peaks of $^{15}ND_3$ separated by 9.45 Hz ($J_{^{15}N\text{-}D}$). Next in magnitude were 10 peaks in two groups of five, the expected spectrum $^{15}NHD_2$ ($J_{^{15}N\text{-}D}$ = 9.45 Hz and $J_{^{15}N\text{-}H}$ = 61.8 Hz). The remaining nine peaks consisted of three groups of triplets separated by 61.8 Hz ($J_{^{15}N\text{-}H}$) each with internal separation of 9.45 Hz ($J_{^{15}N\text{-}D}$), the expected spectrum for $^{15}NH_2D$. No lines for $^{15}NH_3$ were observable in this sample. Sample II contained 23 peaks, the peaks of greatest intensity were those of the $^{15}NH_3$ quartet with $J_{^{15}N\text{-}H}$ = 61.8 Hz. The remaining peaks were the nine-peak $^{15}NH_2D$ and ten-peak $^{15}NHD_2$ spectra with $J_{^{15}N\text{-}H}$ = 61.8 and $J_{^{15}N\text{-}D}$ = 9.45 Hz in each case. The $^{15}N$ chemical shifts for the species $^{15}NH_2D$, $^{15}NHD_2$, and $^{15}ND_3$ relative to $^{15}NH_3$ as an internal standard were measured for the spectra of samples I and II and found to be 0.68, 1.29, and 1.96 ppM upfield of $^{15}NH_3$, respectively. (D.H.M.)

**17420** CHLORINE ISOTOPE EFFECTS ON THE $^{19}F$ RESONANCE OF $CCl_3F$ AND THE USE OF THIS SIGNAL AS A REFERENCE IN HIGH-RESOLUTION NUCLEAR MAGNETIC RESONANCE. Carey, P. R.; Kroto, H. W.; Turpin, M. A. (Univ. of Sussex, Brighton, Eng.). Chem. Commun., No. 5, 188(1969).

It was found that the fluorine resonance of $CCl_3F$ is an unsuitable locking or reference signal for high resolution $^{19}F$ NMR spectra, particularly at low temperatures, where a clear isotope effect is in evidence. $CCl_3F$ exists in the four Cl-isotopic modifications $CF^{35}Cl_3$ (42%), $CF^{35}Cl_2{}^{37}Cl$ (42.9%), $CF^{35}Cl^{37}Cl_2$ (13.6%), and $CF^{37}Cl_3$ (1.5%), and the spectra indicate that the fluorine

shifts in the slightly differing environments of the various isotopic species are sufficiently different to be resolvable. Three peaks with intensities consistent with those expected for the three most abundant species were clearly resolved at −80°. As the temperature was raised the separation between the two strong peaks appeared to decrease until at +30° they were poorly resolved, and the third weaker peak could not be unambiguously identified; the almost unresolved line was very broad. The reference requirement should ideally be a single sharp line. At low temperatures the presence of two equal closely separated peaks reduces the value of the $CCl_3F$ resonance as a locking signal. (UK)

**17421** SYNTHESIS OF METALLIC COMPOUNDS LABELED BY RADIOACTIVE ISOTOPES BY MEANS OF ISOTOPIC EXCHANGE INTERPHASE REACTIONS IN THE AMALGAM-SOLUTION SYSTEMS. Gladyshev, V. P. Radiokhimiya, 10: 754-5(1968). (In Russian).

The exchange reaction used for radiochemical synthesis may be conveniently carried out in a heterogeneous system, such as the one represented by the amalgam−solution system, including the desired metal ion: $Me(Hg) + Me^{n(*)+} \rightleftharpoons Me^{*}(Hg) + Me^{n+}$, whereby $Me^{*}$, $Me^{n(*)+}$, Me and $Me^{n+}$ designate the atoms and ions of the radioactive and nonradioactive isotope of the metal, respectively. The diffusion rate of the isotope from the amalgam to the solution phase limits the process which follows the equation of a first-order reaction. The exchange rate may be increased by stirring. The labeled amalgam may be prepared by the direct dissolution of the neutron-activated portion of the metal in mercury (about $10^{-3}$ % or higher at room temperature), such as Cd, Zn, Tl, In, Sn, Pb, Bi, Cu, etc. The exchange reaction must be carried out under exclusion of oxygen. (TTT)

**17422** X-RAY INVESTIGATION OF THE MODIFICATIONS I–IV OF $NH_4Br$ AND $ND_4Br$ AT TEMPERATURES BETWEEN 196° AND −192°C. Hovi, Vaeinoe; Paavola, Kirsti; Urvas, Olavi (Univ. of Turku, Finland). Ann. Acad. Sci. Fenn., Ser. A VI, No. 291, 1-13(1968).

The lattice parameters of the different modifications of $NH_4Br$ and $ND_4Br$ were determined between 196° and −192°C at 67 and 62 temperatures, respectively. The low-temperature and the high-temperature Debye–Scherrer methods, described earlier by Hovi et al. and by Pöyhönen and Ruuskanen, respectively, were employed. The transition III–IV of $NH_4Br$, observed by Stephenson and Adams below −165°C from specific heat measurements, was found to be a structural one between the caesium chloride and tetragonal structures. The molar volumes, their discontinuous changes at the transition temperatures, and the ratios of the two different lattice parameters of the tetragonal modifications were determined from the experimental lattice parameters for $NH_4Br$ and $ND_4Br$. (auth)

**17423** THE RARE EARTHS: THEIR USES, PROPERTIES, ORES, AND SEPARATION PROCESSES. Le Brun, Jacques. Arts Mfg., No. 187, 23-7(June 1968). (In French).

The occurrence, properties, and uses of rare earth metals and their oxides are reviewed. Various methods used for separation of the rare earths are described. (J.G.B.)

**17424** EQUILIBRIUM PRESSURE OF CO OVER URANIUM OXYCARBIDES IN THE PRESENCE OF $UO_2$. Bazin, J.; Accary, A. (CEA, Saclay, France). Bull. Soc. Fr. Ceram., No. 77, 109-17(Oct.-Dec. 1967). (In French).

When UC is found in the presence of $UO_2$, a chemical equilibrium is set up leading to oxycarbides of varying O content. The equilibrium pressure of CO over this mixture decreases with decreasing O content of the oxycarbide. The reaction leading to formation of CO ceases when the oxycarbide reaches its maximum concentration of O as a function of temperature and pressure, or when the $UO_2$ is entirely consumed. The results are based on the assumption of ideal solid solutions, and therefore are only qualitatively correct; more precise activity measurements are needed. The apparatus is described. The equation governing equilibrium pressure over $UC_{0.997}O_{0.003}$ is: $\log p_{CO} = (-39600/T) + 21.42$. These results are extended in the direction of higher O concentrations to $UC_{0.9}O_{0.1}$ graphically and in tables. (BBB)

**17425** EFFECT OF IRREVERSIBLY ABSORBED WATER ON THE CHARACTER OF THORIUM OXIDE SURFACES. Holmes, H. F.; Fuller, E. L. Jr.; Gammage, R. B.; Secoy, C. H. (Oak Ridge National Lab., Tenn.). J. Colloid Interface Sci., 28: 421-9(Nov.-Dec. 1968).

Adsorption of water, $N_2$, and Ar on $ThO_2$ was studied with a sensitive vacuum microbalance system. Adsorbents used in this study encompassed a wide range of crystallite sizes and specific surface areas. A most important factor was found to be the amount of irreversibly adsorbed water on the surface at the beginning of an adsorption experiment. This was true regardless of the sp surface area, crystallite size, and porosity of the sample involved. Samples containing a relatively large amount of irreversibly adsorbed water presented a surface which exhibited a considerable amount of hydrophobic and nonpolar character. This was true of all 3 adsorbates and was reflected in the shape of the isotherm, the energy of adsorption, and a reduction in apparent surface area. These results contrast sharply with the strongly hydrophobic and polar nature of the isotherms obtained for the bare or hydroxyl-covered surface. The results are attributed to the influence of the substrate lattice on the orientation and hydrogen bonding characteristics of the irreversibly adsorbed water molecules. (BBB)

**17426** VERY SLOW REACTIONS, RATES, AND ISOTOPE EFFECTS IN THE BROMINATION OF 2-BENZOYLBUTANE. Lewis, Edward S.; Allen, James D.; Wallick, Earl T. (Rice Univ., Houston, Tex.). J. Org. Chem., 34: 255-61(Feb. 1969).

The application of a method for following very slow reactions using an isotopic dilution method is described. The particular case studied is the bromination of 2-benzoylbutane (2-methylbutyrophenone) and 2-benzoylbutane-2-d in acetic acid containing sodium acetate. The reaction is not particularly well suited to the method, and the successful application thus illustrates the generality of the method. The rates measured were consistent with those measured at a higher temperature by a gas chromatographic method, which is also applicable to rather slow reactions. Several rates measured by this latter method are also presented. The limitations of various techniques for slow reactions are discussed. Second-order rate constants of less than $10^{-6}$ $M^{-1}$ $sec^{-1}$ were measured. The deuterium isotope effect is given by the equation $k_H/k_D = 0.99 \exp(1280/RT)$, which does not suggest that tunneling is important. The measured rate at the lowest temperature is greater than predicted by the Arrhenius equation for both protium and deuterium compounds; the source is not tunneling but may be mechanistic or experimental error. (auth)

**17427** SPECTROPHOTOMETRIC ESTIMATION OF URANIUM WITH 2-HYDROXY-1-NAPHTHALDOXIME. Reddy, G. Raja (Sri Venkateswara Univ. Coll., Tirupati, India). Curr. Sci. (India), 38: 137-8(Mar. 20, 1969).

A series of uranylaldoxime complex solutions in 50% alcohol was prepared having different concentrations of U by adding the reagent in excess (4 ml). The pH was adjusted to 9.0 to 11.0 with (0.1 N) ammonia and made up to 25 ml. The reagent treated with ammonia (light yellow solution) was used as a blank. Optical densities of these solutions were measured at 470 mμ. Beer's Law was obeyed in the concentration range, 0.5 to 5 mg/25 ml. Spectrophotometric studies also showed that the metal to ligand ratio is 1:2. (P.C.H.)

**17428** MEASUREMENT OF SEPARATION FACTOR IN EXCHANGE REACTION BETWEEN LIQUID AMMONIA AND HYDROGEN. Sakharovskii, Yu. A.; Zel'venskii, Ya. D. At. Energ. (USSR), 25: 499-503(1968). (In Russian).

Experimental measurement of the separation factor for isotope exchange between liquid ammonia and hydrogen in wide interval of temperatures (−70 to +95°C) and pressures (0.5 to 150 atm) was carried out. The method of direct measurement of isotope composition of equilibrium phases was used. Dependence of the separation factor on temperature is described by equation $\lg \alpha = (A/T) + B$, where $A = 235$. It was also shown experimentally that the separation factor significantly depends on deuterium concentration. This dependence corresponds to the equation $\alpha = (2/3)k_1[1 - (\delta y/1 + \delta y)]$. (auth)

**17429** AN ELECTROCHEMICAL METHOD FOR THE DETERMINATION OF THE SOLUBILITY OF HYDROGEN IN LIQUID SODIUM. Newcombe, R. J.; Thompson, J. (Coll. of Tech., Grimsby, Eng.). J. Polarogr. Soc., 14: 104-8(1968).

An electrochemical method is reported by which the solubility of hydrogen in liquid sodium was determined in the temperature range 260 to 290°C. A concentration cell consisting of solutions of hydrogen in liquid sodium separated by a glass membrane is described. Using the same apparatus an independent technique is also described for the simultaneous determination of hydrogen solubility involving measurement of equilibrium hydrogen pressures above the solution. Solubility for both methods is reported and found to be in good agreement. (auth) (UK)

**17430** DETERMINATION OF THE FIRST HYDROLYSIS CONSTANT OF CURIUM. Guillaumont, Robert; Ferreira de Miranda, Carlos; Galin, Monique (Institut de Physique Nucleaire, Val-de-Marne, France). Compt. Rend., Ser. C, 268: 140-3(Jan. 13, 1969). (In French).

The value of the first hydrolysis constant of curium is equal to $(9 \pm 2) \times 10^{-7}$ in a perchloric acid medium with an ionic strength of 0.1. (tr-auth)

**17431** CRYSTALLOGRAPHIC RESULTS ON HYDRATED COMPLEX FLUORIDES OF URANIUM(IV) AND ZINC OR MANGANESE. Charpin, Pierrette; Montoloy, Francois; Nierlich, Martine (CEA, Gif-sur-Yvette, France). Compt. Rend., Ser. C, 268: 156-8(Jan. 13, 1969). (In French).

Results of studies on monocrystals showed that complex hydrated fluorides of uranium(IV) and zinc or manganese are orthorhombic and monoclinic, respectively. (tr-auth)

**17432** COMPOSITION AND STABILITY CONSTANTS OF THORIUM(IV) AND URANIUM(VI) CHELATES WITH DIBROMOPYROGALLOL RED IN AQUEOUS SOLUTION. Pande, Subhash C.; Sangal, Satendra P. (Nagpur Univ., India). Microchem. J., 13: 674-84(Dec. 1968).

The characteristics of the colored chelates of thorium(IV) and uranium(VI) with dibromopyrogallol red are described. Composition of the chelates was determined by absorptiometric measurements. The conditional stability constants were evaluated by two methods. (auth)

**17433** MEASUREMENT OF THE SPECIFIC VOLUMES OF $NH_4Br$ AND $ND_4Br$ BETWEEN 20° AND 140°C BY HYDROSTATIC WEIGHING. Jaakkola, S.; Poeyhoenen, J.; Simola, K. (Univ. of Turku, Finland). Ann. Acad. Sci. Fenn., Ser. A VI, No. 295, 1-15(1968).

The specific volumes of $NH_4Br$ and $ND_4Br$ were observed between 20 and 140°C by using a hydrostatic weighing dilatometer constructed for precision measurements. This dilatometer gives an accuracy of $4 \times 10^{-5}$ for the specific volume of a solid sample. The values 7.486 $cm^3$ and 7.470 $cm^3$ were obtained for the changes of the molar volumes V of $NH_4Br$ and $ND_4Br$, respectively, at the transformation I–II. The volume isotope effect $V_D - V_H$, which was +0.038 $cm^3$/mole (mod. II) and −0.034 $cm^3$/mole (mod. I) at 130°C, was observed to change sign at about 30°C (mod. II) and 160°C (mod. I.). These inversions were observed to be due to an increase of the thermal expansion coefficient of $NH_4Br$ on deuteration. The value 119.5 ± 1°C was obtained for the I–II transformation temperature of $ND_4Br$, which means a shift of −18.3°C with respect to $NH_4Br$. (auth)

**17434** THE INFLUENCE OF THE NATURE, SIZE, AND SYMMETRY OF MOLECULES ON EQUILIBRIUM OF CHEMICAL REACTIONS. III. QUANTITATIVE EVALUATION OF THE EFFECT OF THE LENGTH OF RADICALS ON THE EQUILIBRIUM OF REACTIONS WITH PHOSPHOORGANIC DERIVATIVES. Komarov, E. V.; Shpunt, L. B. Radiokhimiya, 10: 727-9(1968). (In Russian).

Previously obtained equations were used in evaluation of the influence of substituent radical dimensions on the equilibrium of reactions between alkyl derivatives and metallic salts of phosphoric and phosphonic acids. The transition of uranyl nitrate from an aqueous solution into an organic phase, followed by its reaction with reagent A (phosphoorganic reagent) was formulated in two stages: $(UO_2^{2+})_{aq.} + 2(NO_3^-)_{aq.} \xrightarrow{K_I} [UO_2(NO_3)_2]_0$ and $[UO_2(NO_3)_2]_0 + 2A_0 \xrightarrow{K_{II}} [UO_2(NO_3)_2A_2]_0$. A standard reaction of uranyl nitrate with tri-n-butyl phosphate in carbon tetrachloride (where $E_0$ = 37 kcal/mole) was used in the numerical calculations. Results of calculation for reactions with reagents of the type $(C_4H_9O)_3$ ROPO, $(C_4H_9O)_2$ RPO, and $(RO)_2$ $CH_3PO$ are tabulated (R is a variable alphatic radical of normal structure). The final data indicated the applicability of the initial model of calculation and the importance of taking into account even small-dimension substituent radicals. (R.V.J.)

**17435** VAPORIZATION THERMODYNAMICS OF EUROPIUM MONOXIDE. Haschke, John M.; Eick, Harry A. (Michigan State Univ., East Lansing). J. Phys. Chem., 73: 374-7(Feb. 1969).

Europium monoxide prepared by the reduction of the oxide chloride with lithium hydride was studied by the target collection Knudsen effusion technique and found to vaporize according to the reaction $4EuO(s) \rightarrow Eu_3O_4(s) + Eu(g)$ (1), over the temperature range 1334 to 1758°K. At 1546°K, $\Delta H_T^\circ = 75.9_1 \pm 0.9_4$ kcal/gfw and $\Delta S_T^\circ = 28.6_8 \pm 0.6_1$ eu. Heat capacity data for EuO(s) were estimated, and second- and third-law enthalpies for reaction 1 are presented. For EuO(s), $\Delta H_{f\,298}^\circ = -145._2 \pm 4._1$ kcal/gfw, $\Delta G_{f\,298}^\circ = -139._0 \pm 4._1$ kcal/gfw, and $S_{298}^\circ = 15._0 \pm 3._0$ cu. (auth)

**17436** SOLVENT ISOTOPE SHIFTS OF CAESIUM RESONANCES IN DILUTE SALT SOLUTIONS. Halliday, J.; Hill, H. D. W.; Richards, R. E. (Oxford Univ.). Chem. Commun., No. 5, 219-20(1969.

During studies of chemical shifts of Cs nuclear resonance in dilute aqueous and nonaqueous solutions of Cs salts the effects of changes in the isotopic composition of the solvent were examined. The results are stated to throw new light on the mechanism of the isotope effect in such solutions. The measurements for CsCl solutions in $H_2{}^{16}O$, $D_2O$, and $H_2{}^{18}O$ are stated to be of greater precision than earlier results, with extension of the concentration range down to 0.005M. It was concluded that the isotope effects cannot simply be a function of the masses of the molecules, but that at infinite dilution are caused by a change of strength of the solvent hydrogen bonds in passing from $H_2O$ to $D_2O$; the somewhat stronger hydrogen bonds formed by $D_2O$ might easily modify the parameters so as to cause the observed diamagnetic shift. By contrast with low concentrations the shifts at high concentrations all converge at ~4M; this behavior is consistent with the hypothesis that changes of hydrogen bonding are responsible for the shifts. Cs is a structure-breaking ion and at high concentrations the effect of hydrogen bonding in the water is greatly reduced with a consequent increase in the shift in $D_2O$ solutions; the isotope effect is destroyed with the breaking up of the water structure. The chemical shift of $Cs^+$ in methanol and deuterated methanol was also measured; at concentrations near 0.1M a small isotope effect was observed, but the shifts at infinite dilution were all the same. (UK)

**17437** THE MECHANISM FOR EXCHANGE BETWEEN AQUEOUS SOLUTIONS AND DEUTERIUM GAS ON PALLADIUM SURFACES. Holleck, G. L.; Flanagan, Ted B. (Univ. of Vermont, Burlington). J. Phys. Chem., 73: 285-92(Feb. 1969).

The isotopic exchange reactions occurring between D chemisorbed on palladium and solutions of $H_2O$ were investigated. The isotopic content of palladium specimens that had absorbed H and D from $D_2$-stirred solutions was determined by mass spectral analysis. In addition, the electrochemical exchange current was measured during the run by a galvanostatic pulse technique. By comparing the exchange current calculated from the isotopic content of the specimen with the electrochemical exchange current it was found that in very acid solutions an electrochemical exchange mechanism appears to be the only important mode of exchange, whereas, in other pH ranges, an additional exchange mechanism (catalytic) comes into play. (auth)

**17438** THERMOPHYSICAL PROPERTIES OF THE LANTHANIDE OXIDES. IV. HEAT CAPACITIES AND THERMODYNAMIC PROPERTIES OF THULIUM(III) AND LUTETIUM(III) OXIDES. ELECTRONIC ENERGY LEVELS OF SEVERAL LANTHANIDE(III) IONS. Justice, Bruce H.; Westrum, Edgar F. Jr.; Chang, Elfreda; Radebaugh, Ray (Univ. of Michigan, Ann Arbor). J. Phys. Chem., 73: 333-40(Feb. 1969).

The heat capacities of thulium(III) and lutetium(III) oxides were measured from 6 to 350°K. The electronic heat capacity associated with the Tm(III) ion is resolved from the total heat capacity values for the two oxides and that of gadolinium(III) oxide. Several low-lying energy levels for the Tm(III) ion arising from crystal field splitting of the ground term ($^3H_6$) of Tm(III) ion and of related lanthanide(III) ions are discernible. The observed heat capacity values yield for $C_p$, $S^0 - S_T^0$, and $(G^0 - H_T^0)/T$ 24.32, 26.28, and −12.22 cal/(mol °K) at 298.15°K for $Lu_2O_3$ with T′ = 0°K and 27.90, 33.15, and −16.41 for $Tm_2O_3$ with T′ = 10°K. The latter values are extended to a 0°K reference point by estimating a magnetic contribution below 10°K. (auth)

**17439** VISIBLE ABSORPTION SPECTRUM OF URANYL NITRATE HEXAHYDRATE. Sahini, V. E.; Pirtea, Th.; Butucelea, Al. (Inst. of Physical Chemistry, Bucharest). Rev. Roum. Chim., 13: 985-90(Aug. 1968).

The vibrational structure of the 350 to 485 mμ absorption band of $UO_2(NO_3)_2 \cdot 6H_2O$ in 5 aliphatic alcohols, at room temperature and in rigid glasses, was investigated. The frequencies of the $\nu_1$ vibration were measured and the interatomic distances U–O in the $^3\Pi_u$ excited states calculated. (auth)

**17440** TRACER STUDIES OF ACID-CATALYZED REACTIONS. IX. EXCHANGE OF $D_2$ WITH NONCYCLIC OLEFINS OVER ALUMINA. Hightower, Joe W.; Hall, W. Keith (Carnegie-Mellon Univ., Pittsburgh). J. Catal., 13: 161-8(Feb. 1969).

The mechanism of deuterium exchange with hydrogen atoms in small noncyclic olefins was investigated over a pure alumina catalyst. In reactions of 1-butene, cis-2-butene, isobutene, and tert-butylethylene with $D_2$, only the vinyl C–H bonds underwent exchange below 100°C. The exchange occurred most readily with terminal vinyl hydrogen atoms of α-olefins and probably involved a dissociative mechanism on acid-base or ion-pair sites on the dehydroxylated surface. Isomerization and exchange were independent processes. NMR studies of the products obtained at two different temperatures showed that the activation energy for the exchange reaction in isobutene was considerably lower than that for double-bond migration. (auth)

**17441** ISOTOPIC EXCHANGE OF DEUTERIUM BETWEEN HYDROGEN AND WATER VAPOR ON ALUMINA PROMOTED NICKEL. Olariu, Al.; Marginean, P. (Inst. of Atomic Physics, Cluj). Rev. Roum. Phys., 13: 823-8(Oct. 1968).

Measurements on nickel surface area, catalytic activity, and total surface area of alumina promoted nickel have been carried out. As test for the catalytic activity the isotopic exchange of deuterium between hydrogen and water vapor has been used. The experimental results were compared with those previously obtained for chromia promoted nickel. A similarity of results was found. As far as specific activity is concerned the better dispersed alumina promoted nickel was less active than chromia promoted nickel. The role of promoter nature is discussed. (auth)

**17442** INELASTIC SCATTERING OF SLOW NEUTRONS ON ZEOLITE WATER. Pokotilovskii, Yu. N. (Inst. of Chemical Physics, Moscow). Zh. Strukt. Khim., 9: 1079-81(Dec. 1968). (In Russian).

In view of the large neutron scattering cross section of hydrogen, the dynamics of hydrogen-containing molecules may be examined by means of slow-neutron scattering techniques. Therefore, the inelastic scattering spectra of slow neutrons on water molecules adsorbed on commercial zeolites were examined. The noncoherent scattering was measured by means of a time-of-flight spectrometer, placed in a pulsed fast reactor operated at 5 pulses per second The scattered neutrons were passed through a polycrystalline beryllium filter and were measured with a $BF_3$-filled proportional counter, recording only neutrons with an energy of <5.2 MeV. The results indicated that the vibrational spectrum of the water molecules on the mordenite differed only slightly from that of ordinary water. The peak due to torsional vibrations is divided and is shifted toward smaller transferred energies. This might be due to the degradation of the tetrahedral structure of water. The dodecahedra from the tetrahedral configuration are unable to exist in the narrow channels of the mordenite, although the nodules of certain zeolites are sufficiently large to accommodate the water molecules. (TTT)

**17443** KINETIC ANALYSIS OF THE ION–MOLECULE REACTIONS IN NITROGEN–HYDROGEN MIXTURES USING ION CYCLOTRON RESONANCE. Bowers, M. T. (Univ. of California, Santa Barbara); Elleman, D. D.; King, J. Jr. J. Chem. Phys., 50: 1840-5(Feb. 15, 1969).

The thermal energy rate constants for the reactions $N_2^+ + D_2 \xrightarrow{k_1} N_2D^+ + D$; $N_2^+ + H_2 \xrightarrow{k_2} N_2H^+ + H$; $N_2^+ + HD \xrightarrow{k_{4a}} N_2H^+ + D \xrightarrow{k_{4b}} N_2D^+ + H$, were measured using ion cyclotron resonance (icr) giving $k_1 = 1.15$, $k_2 = 1.41$, $k_{4a} = 0.65$, and $k_{4b} = 0.69 \times 10^{-9}$ cm$^3$ molecule$^{-1} \cdot$ sec$^{-1}$. These results agree very well with the values calculated from the change-induced dipole model of Gioumousis and Stevenson. The absence of a significant isotope effect in $k_{4a}$ and $k_{4b}$ indicates these reactions proceed via a stripping mechanism as indicated by Wolfgang and co-workers and Mahan and coworkers. Energy dependence studies of $k_2$ and the corresponding charge exchange rate constant $k_5$ $D_2^+ + N_2 \xrightarrow{k_5} N_2D^+ + D$; $D_2^+ + N_2 \xrightarrow{k_5} D_2 + N_2^+$ indicate that the decrease in $k_2$ with increasing reactant ion energy is approximately offset by the increase in $k_5$ as predicted by the phase-space theory of Light. (auth)

**17444** VIBRATIONAL INTENSITY PROGRESSION IN THE V ← N TRANSITION OF ETHYLENE. McDiarmid, Ruth (National Inst. of Health, Bethesda, Md.). J. Chem. Phys., 50: 1794-1800(Feb. 15, 1969).

The relative intensities of the vibrational subbands of the V ← N transitions of $C_2H_4$ and $C_2D_4$ were measured and compared with the squares of the vibrational overlap integrals of two choices of one-dimensional oscillators (one hindered by a harmonic barrier and one hindered by a sinusoidal barrier). The harmonic oscillator is found to more adequately describe the experimental data. The value of the upper-state A′ rotational constant deduced from the experimental data, 5.45 cm$^{-1}$, precludes structures of the V state in which the carbon atoms lie off the minimum axis of inertia. The difference between A and A′ can be explained by reducing the distance between the geminal hydrogens 5%. The electronic transition moment is shown to be independent of torsional quantum number from v′ = 5-12 ($C_2H_4$) or v′ = 12-18 ($C_2D_4$). In this range of v′ for $C_2H_4$ the oscillator strength is estimated to be 0.1. (auth)

**17445** STUDIES OF URANIUM(VI) COMPLEXES OF OXINE IN CHLOROFORM. Oki, Shohachiro (Shizuoka Univ., Hamamatsu, Japan). Anal. Chim. Acta, 44: 315-22(Feb. 1969).

The solubilities and absorption spectra of uranium(VI)–oxine complexes in chloroform were studied. The solubility of the 1:2 complex in chloroform was found to be $3.99 \times 10^{-4}$ M. In chloroform containing ethanol, the 1:2 complex decomposed: $3UO_2Ox_2 + C_2H_5OH \rightarrow (UO_2Ox_2)_2HOx + UO_2Ox \cdot OH_5C_2$. The solubilities of the 1:3 complex in chloroform and chloroform containing ethanol were $8.35 \times 10^{-4}$ M and $9.86 \times 10^{-4}$ M, respectively. The presence of a 1:4 complex, $UO_2Ox_2 \cdot 2HOx$, was suggested by the decrease in the solubility of the 1:3 complex with increasing amount of oxine in chloroform. The presence of the 1:4 complex was also supported by the spectral change of a solution containing the 1:3 complex when oxine was added to the solution. The absorption spectra of the 1:2, 2:5, and 1:4 complexes are given. (auth)

**17446** UNIT CELL DIMENSIONS OF HYDRAZINE URANIUM(IV) FLUORIDE. Ratho, T.; Patel, T. (Regional Engineering Coll., Rourkela, India). Indian J. Phys., 42: 240-2 (Apr. 1968).

The Debye-Scherrer powder pattern of hydrazine uranium(IV) fluoride $N_2H_5UF_5$ was recorded by a Rigaku camera at room temperature. The powder data analysis shows the crystal to be orthorhombic with a = 7.941 Å, b = 6.372 Å, and c = 7.478 Å. It contains 4 molecules per unit cell and the probable space group is P222 or Pmm2. (auth)

**17447** SUBSTITUTION REACTIONS OF THIOCYANATO COMPLEXES(IV). I. KINETIC ISOTOPIC EFFECTS IN AQUOTIZATION OF TETRAISOTHIOCYANATODIANILINOCHROMATES(III). Thomas, G.; Treindl, L. (Institut fuer Physikalische Chemie, Bratislava. Komensky-Univ., Bratislava). Chem. Zvesti, 22: 809-18(1968). (In German).

The aquotization of $NH_4[Cr(NCS)_4(C_6H_5NH_2)_2]$ in heavy water was followed polarographically between 46 and 58°C and the kinetic isotope effect determined. (M.C.G.)

## Radiation and Nuclear Chemistry

*Refer also to abstracts 17746 and 19158.*

**17448** (JAERI–5018) ACTIVITIES IN THE OSAKA LABORATORY FOR RADIATION CHEMISTRY. Annual Report No. 1, June 1, 1967–March 31, 1968. Sakurada, I. (Japan Atomic Energy Research Inst., Osaka. Osaka Lab.). 1968. 85p. (In English and Japanese). Dep.

Nineteen articles are included; separate abstracts were prepared for 17. The two remaining papers include information on interpretation of mass spectra of methyl-iso-butylketone by quasi-equilibrium theory and identification of the ions in mass spectra of methyl ethyl ether, methyl propyl ether, and diethyl ether by the deuterium labeling method. (P.C.H.)

*For abstracts of individual papers see: 17394, 17449–17463, and 18376.*

**17449** (JAERI–5018, pp 1-4) EFFECT OF ELECTRON RADIATION ON TENSILE PROPERTIES OF CELLULOSE FIBERS. Okada, Toshio; Sakurada, Ichiro (Japan Atomic Energy Research Inst., Osaka. Osaka Lab.). (In English and Japanese).

Studies were made on the effects of 1.5-MeV electrons on tensile properties of Egyptian and Russian cotton, regular rayon staple fiber, high-tenacity rayon staple fiber I and II, and other textiles. The irradiation was carried out in air at a dose from 0.6 to 12 Mrad. Dry and wet strength of the Egyptian cotton was increased about 20% by 0.6 Mrad doses and then decreased rather slowly, whereas that of the Russian cotton decreased continuously. Behavior of three kinds of rayon, the regular- and high-tenacity rayon II and polynosics, was similar, but the behavior of high-tenacity rayon I was quite different from that of the others. Dry and wet strength of the high-tenacity rayon I increased about 20% on irradiation and then decreased with increasing dose. In every case elongation decreased slowly with increasing dose. (auth)

**17450** (JAERI–5018, pp 5-14) RADIATION-INDUCED GRAFT COPOLYMERIZATION TO POLYESTER. I. GRAFTING OF VINYL PYRIDINES TO POLYETHYLENE TEREPHTHALATE FIBERS. Okada, Toshio; Suzuki, Yasuo; Kohdera, Kanako; Sakurada, Ichiro (Japan Atomic Energy Research Inst., Osaka. Osaka Lab.). (In English and Japanese).

Polyethylene terephthalate fibers were grafted with 2- and 4-vinyl pyridine. Noncrystalline fibers (undrawn and non-heat-treated) were used as the starting fibers, which were subjected to γ rays while immersed in aqueous emulsion of 2- and 4-vinylpyridine. In these cases fibers were stuck to each other with a nongraft polymer in the course of the grafting processes. When a small amount of acrylic acid was added to aqueous emulsion of 4-vinylpyridine, grafting took place very smoothly without formation of sticky nongraft polymer. Acidic monomers, such as methacrylic acid, styrene sulfonic acid, maleic acid, etc., can be used in place of acrylic acid. A similar effect was found when a nonpolymerizable organic acid such as formic acid or an inorganic acid such as hydrochloric acid was used. Pretreatment of fibers with carbon tetrachloride was found to increase the rate of grafting. In this case also the addition of small amount of acid, either polymerizable or nonpolymerizable, increased markedly the rate of grafting of 4-vinylpyridine. To show a fair acceptability to acid dyes 15% graft of 4-vinylpyridine was sufficient, while fibers, with more than 20% graft of 2-vinylpyridine did not show good dyabilities. It was found that fibers that were grafted with a mixture of

4-vinylpyridine and acrylic acid (monomer ratio 95 to 80/5 to 20 by volume) had a fair acceptability to acid, basic, disperse, and direct dyes at 2 to 4% graft. Grafted poly(4-vinylpyridine) was quarternized with ethyl- and butylbromide to give modified polyester fibers with much improved hydrophilic properties. (auth)

**17451** (JAERI-5018, pp 15-21) RADIATION-INDUCED GRAFT COPOLYMERIZATION TO POLYESTER. II. GRAFTING OF ACIDIC MONOMERS TO POLYETHYLENE TEREPHTHALATE FIBERS. Okada, Toshio; Suzuki, Yasuo; Kohdera, Kanako; Sakurada, Ichiro (Japan Atomic Energy Research Inst., Osaka. Osaka Lab.). (In English and Japanese).

Grafting of acrylic and methacrylic acid to polyethylene terephthalate fibers was studied by the direct method. Noncrystalline fibers (undrawn and non-heat-treated) were used. When the fibers were immersed in aqueous solutions of acrylic acid and subjected to $\gamma$ irradiation gelation of the reaction mixture took place due to the formation of homopolymer, and it was difficult to separate the graft fibers from crosslinked polyacrylic acid gel. Addition of a small amount of pyridine was found to be effective for retardation of homopolymerization and gelation. Although this method could be applied to the grafting of methacrylic acid, the effect for retardation of homopolymerization was less. The rate of grafting increased with the addition of a small amount of pyridine. An addition of quinoline, isoquinoline, and acridine was found to have similar effect for the grafting of acrylic acid to the fibers. The addition of 2-vinylpyridine and 4-vinylpyridine was found to be more useful than that of pyridine. Graft fibers exhibited a fair acceptability to basic dyes. The sodium salts of the grafts were highly hydrophilic as measured by moisture regain. (auth)

**17452** (JAERI-5018, pp 22-4) EFFECT OF IRRADIATION ON POLYVINYL CAPROATE. Kohdera, Kanako; Okada, Toshio; Sakurada, Ichiro (Japan Atomic Energy Research Inst., Osaka. Osaka Lab.). (In English and Japanese).

Caproylated polyvinyl alcohol and benzoylated PVA were exposed to $\gamma$ rays in vacuo and in air at room temperature. The intrinsic viscosity of caproylated PVA increased to the value 2 times as great as that of nonirradiated material with doses of $6 \times 10^5$ R for vacuo-irradiation and with $7 \times 10^6$ R for air-irradiation. In the case of benzoylated PVA, the intrinsic viscosity remained unchanged in the same dose range. The number of crosslinks produced per 100 eV of energy absorbed G(X), measured by gel formation was estimated to be 3 for vacuo irradiation at room temperature. Crosslinking mainly involved side chains of caproylated polyvinyl alcohol. (auth)

**17453** (JAERI-5018, pp 25-30) VISCOELASTIC BEHAVIOR OF POLY (VINYL ACETATE)-METHYL METHACRYLATE GRAFT COPOLYMER. Suzuki, Yasuo; Okada, Toshio; Sakurada, Ichiro (Japan Atomic Energy Research Inst., Osaka. Osaka Lab.). (In English and Japanese).

Polyvinylalcohol (PVA) was graft polymerized with methyl methacrylate (MMA) by the pre-irradiation technique. To isolate the true graft copolymer from PMMA and ungrafted PVA, extractions were alternately carried out with acetone and water until no polymer was extracted. The isolated true graft copolymer has one branch whose chain length is nearly the same as to that of the backbone polymer. Poly(vinyl acetate) (PVAc) graft with MMA was obtained by acetylation of the PVA-MMA. Viscoelastic properties of grafted PVAc-MMA films, which were prepared by the casting method using benzene and acetone as solvents, were studied and compared with those of films prepared from a polymer blend of PVAc and PMMA. The shape of temperature dispersion curves showed that the component polymers are more or less molecularly mixed in graft copolymer films from benzene or acetone and in blend films from benzene, while the system consists of two separate phases in blend films from acetone. (auth)

**17454** (JAERI-5018, pp 31-3) STUDIES ON THE RADIATION-INDUCED SOLID STATE POLYMERIZATION. II. DIFFERENTIAL THERMAL ANALYSIS OF POST-POLYMERIZATION. Nishii, Masanobu; Hayashi, Koichiro; Okamura, Seizo (Japan Atomic Energy Research Inst., Osaka. Osaka Lab.). (In English and Japanese).

The chain propagation mechanisms of radioinduced polymerization in the solid state were studied by differential thermal analysis (DTA) on the post-polymerization of tetroxane and acrylamide. The DTA curves of both $\gamma$-irradiated monomers were quite different. In the case of tetroxane, the state of monomer phase did not show distinguishable change on the DTA curves of $\gamma$-irradiated tetroxane. It was assumed, that the chain propagation reaction of tetroxane proceeds on condition that the monomer molecules are restrained by monomer crystal lattice force. On the other hand, the state of monomer phase showed distinct change on the DTA curves of $\gamma$-irradiated acrylamide. Hence, it was assumed that the chain propagation reaction of acrylamide proceeds on condition that the monomer molecules are subject to restraint by the monomer crystal lattice force. (auth)

**17455** (JAERI-5018, pp 41-4) ESR SPECTRA OF IRRADIATED PROTEINS. Sugimoto, Shun-ichi; Ohnishi; Shun-ichi; Nitta, Isamu (Japan Atomic Energy Research Inst., Osaka. Osaka Lab.). (In English and Japanese).

The ESR spectra of free radicals produced by irradiation were observed in the single crystal of myoglobin and in the polycrystalline powder of $\alpha$-chymotrypsin, insulin, and lysozyme. The predominant ESR spectrum in myoglobin crystal observed at -196°C, consisted of six lines. This spectrum showed only slightly anisotropy. After the heat treatment at 0°C, doublets appeared (splitting 20 Gauss). The free radical responsible for this spectrum can be assigned to a glycine-type radical (-NH-$\dot{C}$H-CO-). Similar doublets appeared (splitting 175 Gauss) in the spectra of $\alpha$-chymotryspin irradiated under various conditions ($\gamma$ rays, high pressure uv, and 2537 Å). The free radicals for these spectra can also be assigned to the glycine-type radical. (auth)

**17456** (JAERI-5018, pp 45-50) ESR STUDY OF THE RADIATION CHEMISTRY IN THE ADSORBED STATES. I. BENZENE AND ITS DERIVATIVES ADSORBED ON SILICA GEL. Nagai, Siro; Ohnishi, Shun-ichi; Nitta, Isamu (Japan Atomic Energy Research Inst., Osaka. Osaka Lab.). (In English and Japanese).

Benzene, toluene, and three isomers of xylene adsorbed on silica gel were $\gamma$ irradiated at -196°C. ESR spectra observed from these samples were assigned to their respective cation radicals. In the case of benzene, three kinds of radicals were formed; monomer cation radical, dimer cation radical, and cyclohexadienyl radical. Hyperfine coupling constants of methyl protons in the methyl benzene cation radicals were estimated using the hyperconjugation model. Good agreement with observed data was noted. (auth)

**17457** (JAERI-5018, pp 51-4) ESR STUDY OF THE RADIATION CHEMISTRY IN THE ADSORBED STATES. II. PYRIDINE AND VINYL MONOMERS ADSORBED ON SILICA GEL. Nagai, Siro; Ohnishi, Shun-ichi; Nitta, Isamu (Japan Atomic Energy Research Inst., Osaka. Osaka Lab.). (In English and Japanese).

Radioinduced radicals of pyridine and several kinds of vinyl monomers were studied in the absorbed states. ESR spectra observed from the pyridine-silica gel system were complex but the radicals produced seemed to be the cationic species. On the other hand, vinyl monomers on silica gel gave well-resolved ESR spectra and the radicals were produced by H atom addition to the double bond. Cationic species of vinyl monomers could not be observed in the ESR spectra. (auth)

**17458** (JAERI-5018, pp 55-60) EMULSION GRAFT POLYMERIZATION TO WOOD BY $\gamma$-RADIATION. Gotoda, Masao (Japan Atomic Energy Research Inst., Osaka. Osaka Lab.).

Methyl methacrylate (MMA) and/or styrene emulsions of high concentration (50 or 70%) were prepared using suitable emulsifiers. Wood-polymer composites were prepared by irradiating the wood pieces impregnated with the monomer emulsions. The woods used were Swedish birch, pine, beech, and oak. Several reaction conditions such as kind of wood, monomers, and emulsifiers (and also their concentration), were examined. Graft polymerization to wood components was achieved by using this emulsion method, but 100% conversion of the monomer was not attained. Also, a post polymerization effect was observed in the styrene and MMA system, only in the case of a larger concentration of styrene. (auth)

**17459** (JAERI-5018, pp 61-2) SPECTRAL STUDY OF RADIATION-INDUCED THERMOLUMINESCENCE. I. PLASTIC SCINTILLATOR. Nakai, Yohta; Matsuda, Koji; Takagaki, Torao; Kimura, Ki-ichi (Japan Atomic Energy Research Inst., Osaka. Osaka Lab.). (In English and Japanese).

The thermoluminescence spectra of electron-irradiated polystyrene, p-terphenyl, and polystyrene-p-terphenyl solid solutions (plastic scintillators) were studied. Comparison of these spectra indicated that differences among them are not due to the simple energy transfer but the formation of new electronic energy levels in the solid solution of polystyrene-p-terphenyl. (auth)

**17460** (JAERI-5018, pp 65-7) EFFECTS OF THE ELECTRON SCAVENGERS ON THE RADIATION-INDUCED ELECTRICAL CONDUCTIVITY OF n-HEXANE. Takada, Kiyoshi; Hayashi; Kanae; Hayashi; Koichiro; Okamura, Seizo (Japan Atomic Energy Research Inst., Osaka. Osaka Lab.). (In English and Japanese).

The effects of bulky electron scavengers, such as 1,2-benzanthracene, chrysene, pyrene, and naphthacene on the electric conductivity of n-hexane were studied as a function of additive concentration. The results showed that the specific conductivity of pure n-hexane gradually decreased with scavenger concentration to a maximum at approximately $2 \times 10^{-6}$, $2 \times 10^{-4}$, $(2 \sim 10) \times$

$10^{-10}$, and $8 \times 10^{11}$ M, respectively down to a limit value between 0.76 to 0.80. The kinetics of the decreases indicate that bulky molecular anions of the scavengers become predominant as a negative charge carrier instead of thermalized or solvated electron with increasing additive concentration. (P.C.H.)

**17461** (JAERI-5018, pp 68-9) SOME PRELIMINARY MEASUREMENTS ON RADIATION-INDUCED ELECTRICAL CONDUCTIVITY IN n-ALKANES AT LOW TEMPERATURE. Hayashi, Kanae; Hayashi, Koichiro; Okamura, Seizo (Japan Atomic Energy Research Inst., Osaka. Osaka Lab.). (In English and Japanese).

A low-temperature vessel for radioinduced electric conductivity measurements down to –150°C was made and some preliminary measurements on n-alkanes were examined. In a series between n-hexane and n-decane, the decrease of electric conductivity with lowering temperature and with increasing the carbon number of alkanes at a fixed temperature was observed. (auth)

**17462** (JAERI-5018, pp 73-7) SPECTROSCOPIC STUDIES ON THE RADIATION-INDUCED POLYMERIZATION OF ISOBUTENE AT LOW TEMPERATURE GLASSY STATE. Kamiyama, Hideo; Shinkawa, Akihiro; Hayashi, Koichiro; Okamura, Seizo (Japan Atomic Energy Research Inst., Osaka. Osaka Lab.).

A brief review is given on the radioinduced polymerization of isobutene, and the low-temperature polymerization of isobutene in glasses is reported. Studies on the addition of both proton and electron scavengers showed that the polymerization of isobutene in the glassy state proceeds by a cationic mechanism. Electronic spectra and ESR studies to clarify the relation between the active species and the polymerization reaction of isobutene at low temperature are also discussed. A tentative reaction mechanism for the polymerization in the glassy state is suggested. (P.C.H.)

**17463** (JAERI-5018, pp 78-81) STUDIES ON THE FORMATION OF WOOD POLYMER COMPOSITE BY MEANS OF HIGH-ENERGY RADIATION (PRELIMINARY REPORT). Gotoda, Masao; Tsuki, Tadashi (Japan Atomic Energy Research Inst., Osaka. Osaka Lab.). (In English and Japanese).

A wood–polyvinylidene chloride composite was prepared with the use of high energy radiation in attempts to improve the inflammability of wood. The polymerization rate of vinylidene chloride was retarded when the polymerization was carried out in wood. The three species of wood, i.e., Japanese cedar (Cryptomeria japonica), Yezo spruce (Picea jezoensis), and Japanese beech (Fagus crenata) were used for the experiments. Retardation of polymerization was least in the case of Japanese beech, whereas cedar showed greatest retarding effect among the three species of wood studied. The impregnation of wood was also investigated and it was found that Japanese beech was most smoothly impregnated with vinylidene chloride. From these results it was concluded that among the three species of wood Japanese beech is the best for wood–polymer composites. (auth)

**17464** (NYO-2798-41) MASS SPECTRA OF SOME DIMERIC PHOTOPRODUCTS OF PYRIMIDINES. Fenselau, Catherine; Wang, Shih Yi (Johns Hopkins Univ., Baltimore, Md. School of Medicine. Johns Hopkins Univ., Baltimore, Md. School of Hygiene and Public Health). [1968]. 16p. Dep. CFSTI.

The mass spectra of photo-cycloaddition products of thymines and uracils and a photo-coupled product of 5-bromouracil were measured. Characteristic fragmentation was documented for dimers joined through a cyclobutane ring, adducts derived from oxetane and azetidine linkages and a coupled product linked through a 5,5′-bond. (auth)

**17465** INFLUENCE OF THE ELECTRIC FIELD ON THE RADIATION-INDUCED FLUORESCENCE OF AROMATIC HYDROCARBONS IN CYCLOHEXANE. Frankevich, E. L.; Morrow, T.; Salmon, G. A. (Inst. of Chemical Physics, Moscow). JETP Lett. (USSR) (Engl. Transl.), 8: 266-8(Nov. 5, 1968).

Translated from Zh. Eksp. Teor. Fiz., Pis'ma Redaktsiyu, 8: 466-9(Nov. 5, 1968).

The influence of an electric field on the yield of electron-excited singlet molecules of anthracene and pyrene was investigated by studying the fluorescence of solutions of these compounds in cyclohexane. The solutions flowed continuously through a quartz cell containing two parallel platinum electrodes. The volume between the electrodes was irradiated by a continuous beam of 3-MeV electrons. The irradiation caused fluorescence, which was observed in a direction perpendicular to the electron beam by a system containing a set of mirrors, a monochromator, and a photomultiplier. Results indicated that the electric field influences the secondary processes in which charged particles participate and which lead to fluorescence, but not the primary processes of ionization or excitation. (M.C.G.)

**17466** RADIATION EFFECTS ON LUBRICANTS. Bethlendy, G. (Atomic Energy of Canada Ltd., Sheridan Park, Ont.); Andrews, D. G. Eng. Dig. (Toronto), 15: 26-9(Feb. 1969).

Most oils show an increase in viscosity, darken in colour, and develop an acrid odour, if exposed to radiation. They gel and eventually solidify after accumulation of certain amounts of radiation exposure. Some lubricating greases soften first, then harden under radiation. All these changes are the result of polymerization and crosslinking of molecules by ionization, which is the result of radiation. The effects of radiation on lubricants used in nuclear power plants are discussed. (auth) (Canada)

**17467** RADIOLYTIC BEHAVIOR OF SOLID MALONIC AND SUCCINIC ACIDS. Radak, B.; Petkovic, Lj.; Bartonicek, B. (Bortis Kidrich Inst. of Nuclear Sciences, Vinca, Yugoslavia). Int. J. Radiat. Phys. Chem., 1: 77-80(Jan. 1969).

The radiolysis of malonic and succinic acids was studied by reactor mixed radiation and by a pure γ-radiation field. Both acids in both radiation fields were found to decompose so that each original molecule gave one $CO_2$ molecule and a lesser quantity of the fatty acid corresponding to the decarboxylated original acid. The decomposition yield of original compound decreased with increasing number of C atoms in the molecule, and the same was found for the main radiolytic products. (auth)

**17468** PULSE RADIOLYSIS OF $S_2O_8^{2-}$ AND $HSO_5^-$ ANIONS IN AQUEOUS SOLUTION. Roebke, W.; Renz, M.; Henglein, A. (Hahn-Meitner-Institut fuer Kernforschung, Berlin). Int. J. Radiat. Phys. Chem., 1: 39-44(Jan. 1969). (In German).

The absolute rate constants of the reactions of $e^-_{aq}$ and OH with $S_2O_8^{2-}$ and $HSO_5^-$ were determined by pulse radiolysis. The reaction of $e^-_{aq}$ with $S_2O_8^{2-}$ leads to the $SO_4^-$ radical anion. $SO_4^-$ oxidizes $OH^-$ with $k = 4.6 \times 10^7\ M^{-1}s^{-1}$. The rate constants and spectra of the products of some reactions with unsaturated compounds were also determined. $SO_4^-$ acts as a hydroxylating agent with a somewhat slower rate than the OH radical. The reaction between $e^-_{aq}$ and $HSO_5^-$ yields $SO_4^{2-}$ + OH four times more frequently than $SO_4^-$ + $OH^-$. The OH radical reacts with $HSO_5^-$ to form a species which absorbs in the uv, considered to be $SO_5^-$ (or $HSO_5$). (auth)

**17469** THERMAL AND HOT REACTIONS OF CHLORINE ATOMS WITH cis- AND trans-1,2,DICHLOROETHYLENE. Wai, Chien M.; Rowland, F. S. (Univ. of California, Irvine). J. Amer. Chem. Soc., 91: 1053-7(Feb. 26, 1969).

Energetic $^{38}Cl$ atoms react with cis- and trans-1,2-dichloroethylene in condensed phases to form both $^{38}Cl$-labeled isomers of 1,2-DCE, with a preference (ranging between 56/44 and 70/30) for retention of the geometry of the original molecule. Hot substitution of $^{38}Cl$ for H to form $CHCl=CCl^{38}Cl$ is also observed. The reactions observed in the gas phase are consistent with the decomposition of the excited $CHCl^{38}ClĊHCl^*$ formed by addition of $^{38}Cl$ to either isomer of $CHCl=CHCl$. When used in scavenger (3%) concentrations in $CH_3Cl$, the $CHCl^{38}Cl$-ĊHCl* radicals are almost entirely formed by thermal $^{38}Cl$ atom addition. The trans/cis branching ratio for decomposition of excited $CHCl^{38}ClĊHCl^*$ radicals is $0.50 \pm 0.05$, and $\tau < 10^{-10}$ sec for rotation about the C–C bond of this radical. The radical lifetime is about 5 to $7 \times 10^{-10}$ sec when formed by thermal $^{38}Cl$ addition. (auth)

**17470** GAMMA-INDUCED ESTERIFICATION OF SUCROSE AND FATTY ACIDS. Wang, Ung-ping Hua Hsueh, No. 2, 70-8(June 1968).

The γ-ray induced esterification of sucrose with equimolar amounts of various fatty acids was investigated at room temperature. It was found that the esterification of sucrose can be easily carried out with fatty acids of lower molecular weight and that the reaction is greatly retarded as the molecular weight of fatty acid becomes larger. When a mixture of 100 g sucrose and 140 g glacial acetic acid was irradiated with a total γ-ray dose of $4.75 \times 10^6$ R with 0.5 ml 98% $H_2SO_4$ as catalyst, a yellowish brown, water-soluble viscous liquid (86 g) was produced, giving a high yield (98.1%, based on reacted sucrose). The product had the property of causing foaming of its water solution. A discussion is presented on the kinetic mechanisms of esterification of sucrose with glacial acetic acid. The rate of reaction was found to follow 2nd-order kinetics. The assumed reaction mechanism and the calculated G-value for esterification of sucrose are also considered. (BBB)

**17471** CHEMICAL REACTIONS OF HOT HYDROGEN ATOMS WITH METHANOL AND THE BENZENE–METHANOL SYSTEM. Filatov, Z. S.; Dubovol, V. P.; Kukin, P. P. (Moscow State Univ.). Khim. Vys. Energ., 2: 501-7(Nov.-Dec. 1968). (In Russian).

The chemical reactions of hot hydrogen atoms and radiation-chemical reactions in the $CH_3OH–C_6H_6$ system were studied at

70°C in the liquid phase. Hot hydrogen atoms were initiated by the nuclear reaction $^6Li(n,\alpha)T$ and radiation-chemical reactions by alpha stopping and tritium recoil. Yields of HT and $CH_3T$ in pure methanol were equal to 50 and 4.2%, respectively. Yields decreased in the presence of benzene. The relation of $(HT)/(H_2)$ increased ten-fold in the presence of higher concentrations of benzene, but the $(CH_3T)/(CH_4)$ ratio was not changed. The reaction rate constants were determined. Divergences from addition in yields of $CH_2TOH$ and $C_6H_5T$ are explained by the secondary reactions of radicals, obtained on decomposition of excited molecules after substitution of hot hydrogen. (tr-auth)

**17472** UNSTABLE INTERMEDIATES. PART LIX. ELECTRON SPIN RESONANCE STUDIES FROM 4 TO 77°K OF HYDROGEN-BONDED HYDROXYL RADICALS IN γ-IRRADIATED ICE. Brivati, J. A.; Symons, M. C. R.; Tinling, D. J. A.; Williams, D. O. (Univ. of Leicester, Eng.). J. Chem. Soc., A, No. 4, 719-20(1969).

The anomalous ESR spectra obtained at 77°K from hydrogen-bonded hydroxyl radicals in γ-irradiated ice were found to be the result of librations which are frozen out at lower temperatures. Evidence is also given for pairwise trapping of hydroxyl radicals. (auth) (UK)

**17473** FORMATION OF EXCITED STATES BY RECOMBINING ORGANIC IONS. Brocklehurst, B. (Univ. of Sheffield, Eng.). Nature (London), 221: 921-3(Mar. 8, 1969).

The recombination of ions produced as a result of the dissipation of energy from fast particles in organic materials, and in particular the ratio (T/S) of the yields of excited triplet and singlet states resulting from ion recombination, are discussed. The rates of recombination and spin relaxation are compared, and the effects of altering T/S by external means, e.g., magnetic fields and temperature, are considered. (J.G.B.)

**17474** NUCLEAR RECOIL REACTIONS IN POLYNUCLEAR METAL CARBONYLS. Narayan, S. R.; Wiles, D. R. (Carleton Univ., Ottawa). Can. J. Chem., 47: 1019-24(Mar. 15, 1969).

Nuclear recoil reactions were studied in the compounds $Ru_3(CO)_{12}$, $Fe_3(CO)_{12}$, $Fe(CO)_5$, and $W(CO)_6$, to test the hypothesis that the retention would be closely related to the molecular complexity. Retention values were found to be 41, 26, 41, and 52%, respectively, after exhaustive purification, and the hypothesis is concluded to be invalid for these compounds. A recoil yield of 26% is found for $Fe_3(CO)_{12}$ in $Fe(CO)_5$, and 17% for $Fe(CO)_5$ in $Fe_3(CO)_{12}$. Some reactions are suggested, which can account qualitatively for the observed results. The critical stage of the reaction is assumed to be the hot-zone formation of a mononuclear radioactive species $M(CO)_3$ or $M(CO)_4$, which reacts further by various stepwise reactions. A retention of 52 or 64% was found for $W(CO)_6$, depending on whether column chromatography or vacuum sublimation was used as the first step in the separation. The lower value is preferred. (auth) (CANADA)

**17475** RADIOLYSIS OF GASES IN AN ELECTRIC FIELD. I. THE INFLUENCE OF AN ELECTRIC FIELD ON THE AVERAGE CONCENTRATION OF IONS IN AN IONIZATION CHAMBER. Karachevtsev, G. V.; Larin, I. K.; Tal'roze, V. L. (Inst. of Chemical Physics, Moscow). Khim. Vys. Energ., 2: 524-8 (Nov.-Dec. 1968). (In Russian).

The influence of an electric field on the average concentration of charged particles in a flat ionization chamber was examined. Approximate formulas were obtained for the relation λ of the average concentration of ions in the presence and in the absence of an electric field to the magnitude of charged particle mobilities, the coefficient of recombination, and the degrees of spreading on ion electrodes. The value of λ can be both less and greater than unity. The mechanism of the influence of the electric field on the radiolysis of gases at the expense of changes in the average concentration of ions is discussed. (tr-auth)

**17476** STUDY OF THE DISTRIBUTION OF RADICALS IN IRRADIATED ORGANIC MATRICES BY THE METHOD OF ELECTRON SPIN ECHO. Tsvetkov, Yu. D.; Raitsimring, A. M.; Zhidomirov, G. M.; Salikhov, K. M.; Voevodskii, V. V. (Inst. of Chemical Kinetics and Combustion, Novosibirsk, USSR). Khim. Vys. Energ., 2: 529-35(Nov.-Dec. 1968). (In Russian).

Work was carried out to clarify the possibility of application of the method of spin echo to establish the character of radical distribution in solid organic matrices in the process of their accumulation under the action of gamma radiation and in the course of recombination reactions of the radicals. The relation of the relaxation parameter to the average concentration of radicals in these processes was studied. It was established that the relaxation parameter increases with increases in the average concentration of radicals on accumulation. Comparative studies of gamma- and proton-irradiated samples showed that the field of stabilization of the radicals cannot be dispersed. (tr-auth)

**17477** CERTAIN KINETIC RULES OF RADIATION-CHEMICAL OXIDATION OF TETRACHLOROETHYLENE. Poluzktov, V. A.; Dobrov, I. V.; Lyapina, S. A. (Physical-Technical Inst., Moscow). Khim. Vys. Energ., 2: 536-43(Nov.-Dec. 1968). (In Russian).

The kinetics of gamma-induced liquid-phase oxidation of tetrachloroethylene by oxygen at 30 to 120°C were studied. The radiation yields of the main products of oxidation, tetrachloroethylene oxide and the chloroanhydride of trichloroacetic acid, were $1 \times 10^3$ to $7 \times 10^3$ at dose rates from 50 to 300 rad/sec at 116°C. The oxidation rate was proportional to the square root of the dose rate. The activation energy of chain continuation is equal to 8 kcal/mole. It is shown that chloroethylenes are oxidized according to the mechanism for oxidation of hydrocarbons with conjugated double bonds. (tr-auth)

**17478** RADIATION DECOMPOSITION OF PEROXIDES IN A HYDROCARBON ENVIRONMENT. Koritskii, A. T.; Zubkov, A. V. (Inst. of Chemical Physics, Moscow). Khim. Vys. Energ., 2: 544-51(Nov.-Dec. 1968). (In Russian).

The EPR spectra of radicals that were stabilized on radiolysis of chilled solutions of peroxides in toluene or polystyrene were observed. Three forms of secondary reactions in the irradiated samples, initiated by infrared radiation or increasing temperature, were studied. Results obtained are explained on the basis of a premise concerning the heterocyclic mechanism of decomposition of peroxides during low-temperature radiolysis. The basis of this premise is the dissociative capture of electrons by molecules of peroxides and intramolecular regrouping. In addition, ionic and radical particles stabilizing in pairs are formed, which determine the characteristic peculiarities of secondary reactions. (tr-auth)

**17479** COLOR CENTERS IN IRRADIATED POLYSTYRENE WITH ADDITIVES. Koritskii, A. T.; Zubkov, A. V.; Tochin, V. A. (Inst. of Chemical Physics, Moscow). Khim. Vys. Energ., 2: 552-5(Nov.-Dec. 1968). (In Russian).

The optical absorption and EPR spectra of fast-electron-irradiated polystyrene films, which contain small amounts of peroxide impurities, were studied. The results indicate that, in the presence of peroxide, intermediate complexes are formed. These complexes then decompose to anions and radicals. The results confirmed previous conclusions concerning the heterolytic mechanism of radiation decomposition of peroxides in hydrocarbon matrices. (tr-auth)

**17480** CONCERNING THE MECHANISM OF RADIOLYSIS OF AQUEOUS SOLUTIONS OF CELLOBIOSE, MALTOSE, AND GENTIOBIOSE. Kochetkov, N. K.; Kudryashov, L. I.; Yarovaya, S. M.; Nadzhimiddinova, M. T.; Sharpatyi, V. A.; Emanuel, N. M. (Inst. of Chemical Physics, Moscow. Inst. Organic Chemistry, Moscow). Khim. Vys. Energ., 2: 556-61(Nov.-Dec. 1968). (In Russian).

The radiolysis of aqueous solutions of the disaccharides cellobiose, maltose, and gentiobiose was studied for clarification of the mechanism of radiolysis. The influence of the structure of the compounds and the role of products from the radiolysis of water were determined. Kinetics of the decrease in disaccharides, kinetics of the accumulation of the main products of radiolysis, and the main intermediate radical products were studied. (tr-auth)

**17481** MASS-SPECTROMETRIC INVESTIGATION OF PRODUCTS FROM THE THERMAL DECOMPOSITION OF GAMMA-IRRADIATED STRONTIUM SULFATE. Karaseva, L. G.; Zhuravlev, L. T.; Gromov, V. V.; Spitsyn, Vikt. I. (Inst. of Physical Chemistry, Moscow). Khim. Vys. Energ., 2: 562-5(Nov.-Dec. 1968). (In Russian).

Mass spectrometry showed that in gamma-irradiated crystals of strontium sulfate there are excesses of $SO_2$ and $SO_3$, which are formed under irradiation. The process of interaction of electrons, which were trapped in the $SrSO_4$ lattice with the ion radical $SO_4^-$ during annealing, was also investigated. (tr-auth)

**17482** INFLUENCE OF ADDITIONS OF RARE EARTH ELEMENTS ON THE RADIOLYSIS OF CRYSTALLINE ALKALI METAL NITRATES. Boldyrev, V. V.; Lykhin, V. M. (Inst. of Chemical Kinetics and Combustion, Novosibirsk, USSR). Khim. Vys. Energ., 2: 566-8(Nov.-Dec. 1968). (In Russian).

The influence of additions of trivalent ions of the rare earth elements (Ce, La, Pr, and Nd) on the radiolysis of crystals of potassium, sodium, and cesium nitrates was studied. At doses up to $10^{21}$ eV/g the addition of $La^{3+}$ and $Nd^{3+}$ inhibited

radiolysis and decreased the radiation yield of nitrite as a result of formation of a number of cation vacancies in the system and improvements in the conditions of annealing in the system. The capability of $Ce^{3+}$ and $Pr^{3+}$ to convert to the tetravalent state weakened their inhibiting action, apparently as a result of the introduction of additional electrons in the system. A correlation was observed between the type and efficiency of action of additives and the free volume of the crystalline lattice. The inhibiting action of the additives decreased in proportion to the decrease in free volume of the lattice on transition from cesium nitrate to sodium nitrate. (tr-auth)

**17483** CONCERNING THE RADIOLYSIS OF TRIETHYLENEDIAMINOCOBALT CHLORIDE. Neokladnova, L. N.; Shagisultanova, G. A. (Belorussian State Univ., Minsk). Khim. Vys. Energ., 2: 569-70(Nov.-Dec. 1968). (In Russian).

The radiolysis of $[Co\ en_3]Cl_3$ (en is $NH_2CH_2CH_2NH_2$) was studied in neutral and acid solutions and the products determined by spectrophotometry. Gamma dose rates of $3.12 \times 10^{15}$ eV/ml sec were used in the irradiations. The relation of radiolytic yields to dose is shown. The yield first increased with increasing dose and passed through a maximum at a dose of (1.9 to 3.3) $\times 10^{19}$ eV/ml. The yield of radiolytic products also increased with increasing concentration of the complex salt. The effects of KBr, $CH_3OH$, $NaNO_3$, and HCOONa on the radiolysis were determined. Mechanisms of the reactions in radiolysis were determined. (tr-auth)

**17484** UTILIZATION OF ELECTRON PARAMAGNETIC RESONANCE RELAXATION EFFECTS IN RADIATION CHEMISTRY. Muromtsev, V. I.; Akhvlediani, I. G. (Physical-Technical Inst., Moscow). Khim. Vys. Energ., 2: 483-96(Nov.-Dec. 1968). (In Russian).

Known successes in the application of radiospectroscopy to chemistry based on investigations related to the analysis of form, positions, and intensities of EPR and NMR spectra are surveyed. The relaxation processes depend on the structure and the steric distribution of radicals, the structure of solids, and the nature of the interactions of radicals with neighboring molecules or atoms. Relaxation effects are used for distinguishing two or more types of radicals and for establishment of the real shape of the spectra of different types of radicals. Relaxation can also be used to study the statistics of steric distribution of radicals and to establish the average distance between them. Finally, relaxation effects permit information concerning the structure of radicals and the properties of crystalline lattices to be obtained. Utilization of relaxation for analysis of physical-chemical processes in the solid phase is discussed. (tr-auth)

**17485** SOLID-STATE POLYMERIZATION OF ACRYLONITRILE INDUCED BY REACTOR RADIATION. Tabata, Yoneho (Tokyo Univ.). J. Macromol. Sci., Part A, 2: 919-30(Aug. 1968).

The solid-state polymerization of acrylonitrile induced by reactor radiation at low temperature was carried out. The total radiation intensity was high enough and was $1.2 \times 10^8$ rad/hr (0.276 W/g) for solid acrylonitrile. The temperature in the center of monomers was estimated to be −145°C and the average temperature of the specimen −160°C in a liquid-nitrogen irradiation vessel. The initial rate of polymerization was not possible to obtain exactly, but it seemed that the rate is rapid in comparison with other radiations, possibly due to the broad energy spectrum of γ rays. It was found from the viscosity measurements of polymers obtained that the molecular weight of polymers decreases with irradiation time, and the values are lower in experiments with the nuclear reactor than in the other cases with γ rays and fast electrons. It was observed that the yield of polymerization decreases with irradiation time. This may be due to the degradation of polymers by further irradiation with the high-flux fast neutrons. The formation of trans-vinylene was observed. This is a characteristic phenomenon in polymerization induced by reactor radiation or high-energy electrons (>15-MeV). It may also be due to the recoil effects by fast neutrons in the case of the experiments in the nuclear reactor. The absorption at 2210 $cm^{-1}$ was observed only in polymers obtained by reactor experiments. All polymers obtained under experimental conditions used were soluble in dimethylformamide. Appreciably large amounts of stable radicals were observed in the polymers obtained. (BBB)

**17486** STUDY OF IRRADIATED SILICA-ALUMINUM. II. STUDY OF PARAMAGNETIC DEFECTS BY ELECTRON PARAMAGNETIC RESONANCE. Vedrine, Jacques; Dalmai, Gisele; Naccache, Claude; Imelik, Boris (CNRS, Villeurbanne, France). J. Chim. Phys., 65: 2129-37(Nov.-Dec. 1968). (In French).

Studies were made of paramagnetic centers induced by γ-irradiation of silica–alumina. EPR spectrum was analyzed in terms of contributions from nine distinct types of defects in the solid. The h.f. saturation, values of g-parameters, and the role played by the temperature on these signals and centers are determined and discussed. Structures of F and V centers are proposed. It is shown that diamagnetic defects exist in silica–alumina before irradiation and are ionized by γ rays in paramagnetic centers. Inhomogeneity of silica–alumina is confirmed because some of these defects are thought to be formed in the silica network, some others in the alumina network, and one in the silico–aluminate network. (auth)

**17487** INFLUENCE OF γ RADIATION ON DIELECTRIC AND MECHANICAL PROPERTIES OF POLY(METHYL METHACRYLATE) AND POLYPROPYLENE. Sauerbrey, H.; Suhr, H. (Physikalisch-Technische Bundesanstalt, Berlin). Kolloid-Z. Z. Polym., 225: 121-5(Aug. 1968). (In German).

The dielectric and mechanical loss factors and the dielectric constant of polypropylene and poly(methyl methacrylate) were investigated as a function of γ-radiation dose; the maximum dose was $5 \times 10^7$ R. Studies were carried out in the frequency range between 50 Hz and $10^4$ Hz and in the temperature range between 20 and 140°C. Polypropylene showed an enlarged loss factor; a shift of the dielectric loss factor maximum to higher temperatures was observed. The half-width of the dielectric loss factor of poly(methyl methacrylate) increased slightly. The activation energy for polypropylene increased by 4 Kcal/mole at maximum dose in air; that for polymethylmethacrylate increased by 5 Kcal/mole. The data for the latter suggest a minimum in the activation energy near $10^7$ R. The shift is believed to be the result of an increase in dipole moment. (BBB)

**17488** EFFECTS OF IRRADIATION BY FISSION PRODUCTS. Lesueur, D.; Bloch, J. (CEN, Fontenay-aux-Roses, France). Bull. Soc. Fr. Ceram., No. 78, 47-52(Jan.-Mar. 1968). (In French).

A bibliography of the effects of irradiation by the fission products of $^{235}U$, particularly with respect to refractory materials such as oxides and silicates, is given. The theory of elastic collisions and ionization by radiation is presented; in particular thermal effects in the vicinity of the particle track are discussed. Results of specific studies include the loss of crystallinity of the oxides of Al, Be, and U, and of zircon, under heavy dosage. Particular attention is directed to the loss of crystalline structure in mica at a dose of $1.5 \times 10^{13}$ fission products/$cm^3$. The variation of other physical properties with dose is noted briefly. Applications of irradiation in refractories, particularly mica, are suggested: measurement of integral flux of thermal neutrons, measurement of low concentrations of fissionable impurities, and possibly the preparation of ultrafilters for biological studies. (BBB)

**17489** THE EFFECT OF AROMATIC ADDITIVES ON THE RADIOINDUCED DEGRADATION OF POLY(METHYL METHACRYLATE). I. INFLUENCE OF CONCENTRATION AND MESOMERISM. Wuendrich, K. (Bundesanstalt fuer Materialprufung, Berlin). Kolloid-Z. Z. Polym., 226: 116-24(Oct. 1968). (In German).

The posteffect and the effects of oxygen on the degradation of poly(methyl methacrylate) (PMMA) exposed to $^{60}Co$ γ rays were studied. The radioinduced scissions of the main chain were not affected by oxygen. Mixtures of PMMA and several aromatic additives (benzene, naphthalene, biphenyl, anthracene, phenanthrene, pyrene, and benz(α)anthracene) were irradiated. The degradation was measured by means of solution viscosity. The additives decreased the yield of fractures which was constant over a dose range of 0 to 60 Mrad. A radiation protection factor was defined. Its concentration dependence was derived by means of reaction kinetics and verified by measurements. Accordingly, at low concentrations the radiation protection factor was proportional to the concentration. A molar protection coefficient was also introduced, which increased with the resonance energy of the additives. The results are consistent with the view that the protective effect is due to transfer of excitation energy to the additives and to their electron scavenging. (BBB)

**17490** PREPARATION OF CARRIER-FREE RADIONUCLIDES FROM CYCLOTRON TARGETS BY CONTINUOUS ELECTROPHORESIS. I. SEPARATION OF $^{55}Fe$ FROM MANGANESE, $^{54}Mn$, AND $^{56\ 57\ 58}Co$ FROM IRON, $^{65}Zn$ FROM COPPER, AND $^{109}Cd$ FROM SILVER TARGET. Proso, Z.; Pucar, Z. (Ruder Boskovic Inst., Zagreb). J. Radioanal. Chem., 2: 243-53(Mar. 1969).

Continuous electrophoretic separation of the components of manganese, iron, copper, and silver cyclotron targets bombarded with deuterons is described. The rates of separation were: manganese target, 4.4 mg Mn/hr; iron target, 1.5 mg Fe/hr; copper target, 1.7 mg Cu/hr; and silver target, 6.7 mg Ag/hr. The radionuclides were separated in carrier-free form and were of high radiochemical purity. The results are represented by radioautographs of the continuous electrophoretic processes, and by dia-

grams showing the distribution of the target material and of radioactivity along the collecting glasses. The radiochemical purity of the separated radionuclides was checked by gamma spectra, by estimation of the beta-energies, and by evaluation of the decay curves. (auth)

**17491** ELECTRON SPIN RESONANCE SPECTRUM OF THE $O_2^-$ RADICAL ION TRAPPED IN NON-IONIC MATRICES AT 77°K. Bennett, J. E.; Mile, B.; Thomas, A. (Thornton Research Centre, Chester, Eng.). Trans. Faraday Soc., 64: 3200-9(Dec. 1968).

Trapped electrons are formed when alkali metal atoms are deposited on water or alcohols at 77°K in the rotating cryostat. When trace amounts of oxygen, however, are also admitted during deposition, the deep colour and characteristic electron spin resonance (ESR) spectrum of the trapped electrons are absent. Instead, the deposit is white and gives a highly asymmetric ESR spectrum which has basically the same form in all of the solvents. The principal value $g_\parallel$ of the g-factor, however, varies slightly, but significantly, with the solvent in which the radical ion is trapped. Identical spectra in the corresponding solvents are observed from frozen samples of water or alcohols which were saturated with oxygen and then irradiated at 77°K with $^{60}$Co $\gamma$ rays; and also from samples which were prepared by rapidly stirring sodium superoxide $NaO_2$ into the solvent at room temperature and then immediately freezing the resultant slurry in liquid nitrogen (77°K). All of the ESR spectra observed in these experiments arise from the $O_2^-$ radical ion which is trapped by an assembly of solvent molecules similar to that postulated for electrons trapped in the same solvents. The variation of $g_\parallel$ with the solvent in which the radical ion is trapped is similar to that found for the energy of the maximum absorption in the optical spectra of electrons trapped in these solvents and reflects the degree of interaction between the ion and the solvent. (auth) (UK)

**17492** ENERGY TRANSFER IN THE RADIOLYSIS OF GASEOUS MIXTURES OF ETHYLENE AND CARBON MONOXIDE. Russo, S.; Munari, S.; Biagini, E. (Centro Nazionale di Chimica delle Macromolecole, Genoa. Univ., Genoa). J. Phys. Chem., 73: 378-81(Feb. 1969).

Gas chromatographic analyses were carried out for radiolysis products of irradiated ethylene–carbon monoxide mixtures. The dependence of $G_{C_2H_4}$, $G_{H_2}$ and $G_{CO}$ on their respective feed compositions suggests the presence of an energy transfer process from CO to $C_2H_4$. A kinetic scheme for the formation rates of acetylene and hydrogen, based on the energy transfer, agrees with the experimental results and enables the behavior of the initiation rate for the copolymerization to be determined. (auth)

**17493** PRODUCTION OF PERCHLORATE AND CHLORITE IONS IN CRYSTALLINE POTASSIUM CHLORATE IRRADIATED WITH $^{60}$Co $\gamma$ RAYS. Brown, L. C.; Boyd, G. E. (Oak Ridge National Lab., Tenn.). J. Phys. Chem., 73: 396-400(Feb. 1969).

The production of perchlorate and chlorite ions in crystalline $KClO_3$ irradiated with $^{60}$Co $\gamma$ rays at ca. 30°C was demonstrated by infrared absorption measurements. Quantitative determinations of the concentration of $ClO_4^-$ ions in the solid were performed, and the results were compared with chemical analyses for perchlorate in aqueous solutions of the irradiated solid. The concentrations of $ClO_4^-$ in solution and in the crystal were found equal within experimental error. Accordingly, the hypothesis that the perchlorate observed in solution was produced by the hydrolysis of $Cl_2O_6$ assumed to be present in the solid was unnecessary. Radiolytic yields for the species $Cl^-$, $ClO^-$, $ClO_2^-$, and $ClO_4^-$ were obtained. The concentrations of the first three species appeared to increase linearly with the absorbed dose to a dose as great as $4.4 \times 10^{22}$ eV (mol of $KClO_3$)$^{-1}$; the concentration of $ClO_4^-$ ion, however, increased less rapidly than linearly at large doses. Interesting similarities between the radiolytic and thermal decompositions of the alkali metal chlorates were noted. (auth)

**17494** RECOIL TRITIUM REACTIONS WITH METHYLSILANES. Tominaga, T.; Hosaka, A.; Rowland, F. S. (Univ. of California, Irvine). J. Phys. Chem., 73: 465-6(Feb. 1969).

A study of energetic reactions of tritium with tetramethyl- and trimethylsilane is reported. The products obtained were HT, $CH_3T$, $RCH_2T$, and RT. A very substantial effect of $O_2$ on the HT yields was observed; however, no unusually high yield of HT, or difference in the total reactivity of the methylsilanes with hydrocarbons were found. In one set of samples more heavily irradiated than the other, a substantial depletion of $O_2$ during irradiation was observed, accompanied by an increase in HT yield and the appearance of additional labeled products not found in the well-scavenged samples. It was concluded that tetramethylsilane behaves very similarly to hydrocarbons, both with respect to reactivity and in sensitivity toward $O_2$ scavenger. Experiments with trimethylsilane show, just as with isobutane, a decrease in HT yields with $O_2$ scavenger. The total reactivity toward abstraction was not very different (±15%) for isobutane and trimethylsilane, suggesting that abstraction from tertiary C-H is quite similar to that from tertiary Si-H bonds. (D.H.M.)

**17495** RADIOLYSIS OF SOLUTIONS OF PERFLUOROCARBONS IN n-HEXANE. Rajbenbach, L. A. (Soreq Nuclear Research Centre, Yavne, Israel). J. Phys. Chem., 73: 356-60(Feb. 1969).

The radiolytic yields of hydrogen and hydrogen fluoride in dilute solutions of perfluorocarbons in n-hexane were determined, as well as the yields of cyclohexene and bicyclohexyl in solutions of perfluorocyclobutane in cyclohexane. The larger perfluoroalkane molecules, beginning with $C_4F_{10}$, were found to depress the hydrogen yield. The reduction in hydrogen yield was accompanied by formation of HF. The ability of perfluoroalkanes to reduce the hydrogen yield is correlated with data on resonant attachment of thermal electrons to some of these solutes in the gas phase. The decrease in hydrogen yield in the presence of unsaturated perfluorocarbon solutes is attributed to electron scavenging. Possible mechanisms for the formation of HF are discussed. The low yield of HF in the presence of unsaturated solutes is explained as being due to the ability of perfluoroolefin anions to extract protons from molecular solvent cations. The absence of any effect of perfluoroalkane solutes on the yield of olefins from the corresponding alkane solvent is interpreted as confirming the assumption that charge neutralization reactions between molecular cations and electrons do not lead to the formation of molecular hydrogen. (auth)

**17496** IONIZATION CURRENT MEASUREMENTS AND THE ENERGY REQUIRED TO FORM AN ION PAIR IN $\gamma$-RAY IRRADIATED GASES. Cooper, R.; Mooring, Rose-Marie (Univ. of Melbourne, Parkville, Australia). Aust. J. Chem., 21: 2417-26(Oct. 1968).

Ionization current measurements in $^{60}$Co $\gamma$-irradiated gases were used to determine the average energy required to form an ion pair (W value) in a series of gases. Using well-established values of W for 6 gases ($H_2$, He, air, $N_2$, Ar, and $C_2H_2$), two methods of determining W from further experimental data were devised. Correlation of W with observed ionization current data was achieved using (a) a modified version of the Bethe equation, and (b) available stopping powers. W values for some other gases were determined by both treatments, and the results from each method compared. W values determined by the two treatments were reasonably self-consistent. Excellent agreement was obtained for $O_2$, $N_2O$, $NH_3$, $C_2H_4$, $CH_2Cl_2$, and $(CH_3)_2CO$ for the 2 methods. When the W values showed lack of concordance with data obtained by other workers, possible gas purity and nonsaturation ion collection conditions were considered to be responsible. (BBB)

**17497** SOLID-STATE POLYMERIZATION OF ACRYLONITRILE INDUCED BY Li/He RECOIL PARTICLES AT LOW TEMPERATURE. Tabata, Yoneho (Tokyo Univ.). J. Macromol. Sci., Part A, 2: 931-42(Aug. 1968).

Solid-state polymerization of acrylonitrile, induced by reactor radiation including recoil particles from the reaction $^{10}B(n,\alpha)^7Li$, was carried out at low temperature. The effect of the recoil particles on polymerization was significant. The effect is characterized by crosslinking of polymers produced, and formation of trans-vinylene and C=C bonds conjugated with a bond C=N group in the polymerization during irradiation. (BBB)

**17498** EFFECT OF IONIZING RADIATION ON A SERIES OF SATURATED POLYESTERS. D'Alelio, G. F.; Haberli, Roland; Pezdirtz, George F. (Univ. of Notre Dame, Ind.). J. Macromol. Sci., Part A, 2: 501-88(May 1968).

The effects of ionizing radiation on a series of saturated linear polyesters containing the repeating unit $+OC-R_1-COO-R_2-O+_n$, in which $R_1$ and $R_2$ are linear or branched alkylene groups, are reported. Crosslinking and scission were found to be influenced greatly by the structural features of $R_1$ and $R_2$ and the intrinsic viscosities of the polymers. A dose-rate independence was observed for the polymers in vacuo, whereas in air, degradation was related to diffusion of the gas into the polymer. Amorphous polymers were found to crosslink more readily than the crystalline and oriented polyesters; trapped radicals in the crystalline polymers caused delayed crosslinking when the polymers were subsequently heated. A fundamental difference was found for the grafting of monovinyl and multivinyl monomers to the polyesters. Multivinyl monomers were much more efficient than monovinyl monomers in producing crosslinks and caused crosslinking in polyesters that normally degrade on irradiation alone or in the presence of monovinyl monomers. The term "bridge grafting" is proposed for this effect of the multivinyl monomers; bridge grafting can be applied to a large number of polymers to reduce the irradiation dosage in those polymers which crosslink readily, and crosslink readily those polymers that crosslink with difficulty, or not at all, because of high scission degradation. (BBB)

**17499** ON THE pH DEPENDENCE OF $G_{reducing}$ IN THE RADIATION CHEMISTRY OF AQUEOUS SOLUTIONS. Czapski, G.; Peled, E. (Hebrew Univ., Jerusalem). Israel J. Chem., 6: 421-36(July-Aug. 1968).

The reducing radical formed in irradiated aqueous solutions exists in 2 different forms: the H atom and the solvated electron ($e_{aq}$). Both H and the $e_{aq}$ are formed simultaneously in irradiated neutral solutions. The $N_2O$ + ferrocyanide system and the $N_2O$ + 2-D-2-propanol system were studied to determine why the observed increase of 0.4 to 1.0 units occurs in $G_{red}$ (G value for the reducing radical) when the pH is raised over the range of 9 to 14. Irradiation was carried out with $^{137}Cs$ and 200-kV x rays. The value of $Ge_{aq}$ in neutral solution was found to be 2.7 ± 0.1. Lower values are due to neglect of back reactions. The present results, as well as results from other sources, indicate no dependence of $G_{red}$ on the pH in alkaline solutions. There seemed to be no good evidence that either $G_H$ or $Ge_{aq}$ are pH dependent in alkaline solutions. Hence, in neutral and alkaline solutions the following values were obtained: $Ge_{aq}$ = 2.7 ± 0.1, $G_H$ = 0.6 ± 0.1, and $G_{red}$ = 3.3 ± 0.15. Most of the increases observed in $Ge_{aq}$ in irradiated alkaline $N_2O$ systems can be accounted for by the absence of an H scavenger in these systems. At low pH, the H atom reacts with the radiation product, while at high pH it is converted into an $ee_{aq}$ and reacts with $N_2O$. (BBB)

**17500** PULSE-RADIOLYSIS OBSERVATION OF MOLECULAR CATIONS OF AROMATIC COMPOUNDS IN HALOGENATED LIQUIDS. Arai, Shigeyoshi; Ueda, Hisashi; Firestone, Richard F.; Dorfman, Leon M. (Ohio State Univ., Columbus). J. Chem. Phys. 50: 1072-7(Feb. 1, 1969).

Electron irradiation of dilute solutions of aromatic compounds in liquid chlorinated hydrocarbon solvents results in the formation of the molecular cations of these aromatic compounds. The optical absorption spectra of the molecular cations of diphenyl, p-terphenyl, t-stilbene, and anthracene were observed by pulse-radiolysis methods, and the identity of the reactive species established from the spectra and from various scavenger effects. At room temperature the half-life of these cations in the particular solutions is on the order of a few microseconds. In solutions containing two different aromatic compounds as solutes, it was found that an electron transfer may take place between the neutral aromatic molecule of one compound and the molecular cation of the other. (auth)

**17501** PRAKTIKUM DER ANGEWANDTEN RADIOAKTIVITAET. (Handbook of Applied Radioactivity). Herforth, Lieselott; Koch, Hartwig. Berlin, VEB Deutscher Verlag der Wissenschaften, 1968. 525p. DM 48.--.

Topics covered include: radiation detectors (ionization, scintillation, and semiconductor); measurement of alpha, beta, and gamma radiation and neutrons; activity measurements; dosimetry and radiation protection; use of radioisotopes in industry; separation and enrichment of radioisotopes by precipitation, ion-exchange chromatography, solvent extraction, radiochromatography, distillation, Szilard–Chalmers effect, and chemical effects of radioactive decay; activation, isotopic-dilution, and radiometric analyses, ring-oven methods, and solubility determinations; radioisotopes as tracers; and carbon-14 and tritium incorporation in compounds. (M.C.G.)

## Separation Processes

*Refer also to abstracts 17323, 17335, 17347, 17354, 18019, 18203, 18204, 18235, 18259, 19461, and 19462.*

**17502** (AEC-tr-7028) DEPARTMENT OF CHEMISTRY SEMIANNUAL REPORT, JUNE 1967–NOVEMBER 1967. (Commissariat a l'Energie Atomique, Fontenay-Aux-Roses (France). Centre d'Etudes Nucleaires). Translated for Oak Ridge National Lab., Tenn., from pp 67-79; 146-224; 226-55; 314-34; 343-84; 393-401 of report CEA-N-969. 209p. Dep. CFSTI.

Topics covered include: treatment of low- and medium-level effluents, aqueous reprocessing methods, semiworks treatment of degraded trilaurylamine, separation processes, vitrification of fission product solutions, and formation of a third phase in trilaurylamine. Separate abstracts were prepared for each of the six sections. (M.C.G.)

*For abstracts of individual sections see: 17387 and 17503–17507.*

**17503** (AEC-tr-7028, pp 1-13) TREATMENT OF MEDIUM- AND LOW-LEVEL EFFLUENTS. (Commissariat a l'Energie Atomique, Fontenay-Aux-Roses (France). Centre d'Etudes Nucleaires). Translated from pp 67-79 of report CEA-N-969.

A test run was carried out by combining an ion exchange process with chemical treatment for decontamination of effluents. Laboratory tests were conducted to improve the binding of radioisotopes in resins. Precipitation and bacterial leaching were also studied for waste processing. (M.C.G.)

**17504** (AEC-tr-7028, pp 14-96) STUDY OF AQUEOUS REPROCESSING METHODS, LABORATORY. (Commissariat a l'Energie Atomique, Fontenay-Aux-Roses (France). Centre d'Etudes Nucleaires). Translated from pp 146-224 of report CEA-N-969.

The behavior of a graphite diffusion barrier in chemical treatment of fuels based on natural uranium was investigated. Centrifuging appeared to be the best industrial process for separation of the graphite. Oxidation-reduction reactions for adjustment of plutonium to a valence of 4 were studied. The influence of sulfuric and oxalic acids on the distribution coefficients of Pu in the system $HNO_3$–TBP was determined. Suppression of interphase precipitates and undesirable reactions of zirconium in irradiated fuel processing are discussed. Tests on centrifugal extractors are described. Purification of fuels based on highly enriched uranium alloys by a process using a silica gel column and purification of Pu by extraction with trilaurylamine were investigated. Treatment of irradiated thorium is also discussed. (M.C.G.)

**17505** (AEC-tr-7028, pp 97-130) SAPTCI: SEMIWORKS TREATMENT OF A LOT OF DEGRADED TRILAURYLAMINE (TLA). (Commissariat a l'Energie Atomique, Fontenay-Aux-Roses (France). Centre d'Etudes Nucleaires). Translated from pp 226-55 of report CEA-N-969.

In the process to regenerate the TLA–dodecane solvent, dilaurylamine formate (DLA) is subjected to selective and quantitative precipitation. The TLA is displaced from its salt by DLA, which then precipitates in the form of formate. A processing line for enriched-uranium alloys consists of two pulsed columns in the first decontamination cycle, operating in a continuous organic phase. The hydraulic behavior of the equipment was examined. Searches were made for pulsing parameters offering good efficiency. (M.C.G.)

**17506** (AEC-tr-7028, pp 131-53) RESEARCH AND DEVELOPMENT OF SEPARATION PROCESSES. (Commissariat a l'Energie Atomique, Fontenay-Aux-Roses (France). Centre d'Etudes Nucleaires). Translated from pp 314-34 of report CEA-N-969.

The recovery of $^{237}Np$ in irradiated fuel processing plants is considered. Np, Pu, and U separations were studied. (M.C.G.)

**17507** (AEC-tr-7028, pp 154-98) STUDY OF THE VITRIFICATION OF FISSION PRODUCT SOLUTIONS. (Commissariat a l'Energie Atomique, Fontenay-Aux-Roses (France). Centre d'Etudes Nucleaires). Translated from pp 343-84 of report CEA-N-969.

Vitrification of solutions from low-alloyed uranium processing was studied. Refining of vitrification additive suspensions, testing a furnace for pot vitrification, continuous calcination of solutions from fuel reprocessing, and alumina bed on capsulation from volatility processing are discussed. (M.C.G.)

**17508** (ANL-Trans-703) DEPARTMENT OF CHEMISTRY SEMI-ANNUAL REPORT, JUNE 1967–NOVEMBER 1967. (Commissariat a l'Energie Atomique, Fontenay-Aux-Roses (France). Centre d'Etudes Nucleaires). Translated for Argonne National Lab., Ill., from Sect. 4, 86-92; Sect. 5, 93-123; Sect. 9, 284-312; Sect. 11.4, 382-4 of report CEA-N-969. 88p. Dep. CFSTI.

The four sections translated cover the following topics: electrochemical studies, corrosion studies, dry process methods, and coating of alumina beds coming from the fluorine treatment. A separate abstract was prepared for each of the four sections. (M.C.G.)

*For abstracts of individual sections see: 17389, 17509, 17510, and 18180.*

**17509** (ANL-Trans-703, pp 45-84) STUDY OF DRY PROCESS METHODS. (Commissariat a l'Energie Atomique, Fontenay-Aux-Roses (France). Centre d'Etudes Nucleaires). Translated from Section 9 of report CEA-N-969.

Treatment of U–Zr and U–Al alloys and stainless steel-clad $UO_2$–$PuO_2$ mixtures by the halide volatility process and discontinuous pyrometallurgic decladding are described. (M.C.G.)

**17510** (ANL-Trans-703, pp 85-8) STUDY OF THE COATING OF THE ALUMINA BEDS COMING FROM THE FLUORINE TREATMENTS. (Commissariat a l'Energie Atomique, Fontenay-Aux-Roses (France). Centre d'Etudes Nucleaires). Translated from Section 11.4 of report CEA-N-969.

Possible glass compositions for coating alumina beds were evaluated. (M.C.G.)

**17511** (BLG-429) THERMODYNAMIC CONSIDERATIONS RELATING TO FLUORIDE VOLATILITY PROCESSING OF NUCLEAR FUELS. THE SEPARATION OF URANIUM FROM PLUTONIUM BY SELECTIVE FLUORINATION OF THE URANIUM TO

THE VOLATILE HEXAFLUORIDE. Coenen, F. (Centre d'Etude de l'Energie Nucleaire, Brussels (Belgium)). Aug. 1968. 22p. Dep.

Thermodynamic calculations related to the reprocessing of nuclear reactor fuels by fluid-bed fluoride volatility techniques are presented. The reactions of both uranium and plutonium compounds with fluorine and interhalogens containing fluorine are considered. The effect of the nature of the interhalogens or interhalogen mixtures and of temperature on the equilibrium $PuF_6$ pressure were evaluated, discussed, and illustrated. (auth)

**17512** (EURFNR-581) REPROCESSING FUEL ELEMENTS FOR FAST BREEDERS. Ochsenfeld, W. (Kernforschungszentrum, Karlsruhe (West Germany). Institut fuer Heisse Chemie). Translation of report KFK-852. 14p. Dep. CFSTI.

Work Performed under United States-Euratom Fast Reactor Exchange Program.

The recovery and purification of plutonium, uranium, and nuclear fuel actinides are considered. Advantages of joint aqueous processing of blanket and core are discussed. (M.C.G.)

**17513** (GAMD-9089) HTGR FUEL REPROCESSING: EFFECTS OF SOME FUEL DESIGN CHANGES ON REPROCESSING COSTS. Shefcik, J. J. (Gulf General Atomic, Inc., San Diego, Calif.). Nov. 15, 1968. Contract AT(04-3)-167. 12p. Dep. CFSTI.

Proposed changes in fuel design have little effect on the reprocessing plant capital cost and on the reprocessing costs in terms of dollars per year. Reprocessing costs in terms of dollars per kilogram have an inverse relationship to the quantity of thorium plus uranium in the fuel. Reprocessing costs in terms of dollars per fuel element or mills per kilowatt-hour are less sensitive to the quantity of thorium plus uranium contained in the fuel. Some reduction in reprocessing costs are possible if the quantity of SiC coating material on the uranium particles can be reduced. This reduction could be achieved by increasing the size of the uranium particle kernel or by reducing the thickness of the buffer carbon coating. (auth)

**17514** (IN-1270) FACTORS INFLUENCING THE RATE OF SILICA GEL FORMATION IN HIGH ACID-SALT SOLUTIONS. Cranney, D. H.; Musgrave, B. C. (Idaho Nuclear Corp., Idaho Falls). Feb. 1969. Contract AT(10-1)-1230. 15p. Dep. CFSTI.

Means of influencing the rate of gelation of silicic acid in nitric acid-nitrate salt solutions or of controlling the gel were evaluated. The effect on gelation rate of acidity, salt concentration, silicic acid concentration, and temperature are given. A number of amines, functioning as hydrogen bonding agents, were relatively ineffective in altering gelation rate. (auth)

**17515** (IS-T-285) PREDICTION OF EQUILIBRIUM DATA FOR THE SOLVENT EXTRACTION SYSTEM $SmCl_3$-$NdCl_3$-HCl-$H_2O$ WITH THE EXTRACTANT DI-(2-ETHYLHEXYL) PHOSPHORIC ACID IN AMSCO. Ioannou, Tom Kyriacou (Ames Lab., Iowa). Nov. 1968. Contract W-7405-eng-82. 53p. Dep. CFSTI.

Thesis.

Equilibrium data were obtained for the single-component systems $MCl_3$-HCl-$H_2O$-1 M D2EHPA (in Amsco Odorless Mineral Spirits), where M is trivalent Sm or Nd, for a wide range of acidities and aqueous concentrations. Also equilibrium data were obtained for the system $SmCl_3$-$NdCl_3$-HCl-$H_2O$-1 M D2EHPA-Amsco. The separation factor for Sm with respect to Nd for this system remained constant with an arithmetic average of ~7.67 under all conditions studied. An empirical technique was proposed for predicting equilibrium data for the binary systems based on data for single component systems. It is anticipated that this technique can be extended to other binary systems and also to multicomponent systems. (auth)

**17516** (JAERI-5017, pp 83-8) RADIOACTIVE WASTE TREATMENT AND DECONTAMINATION. (Japan Atomic Energy Research Inst., Tokyo). (In Japanese).

The duties of the Waste Disposal and Decontamination Section are radioactive waste treatment and decontamination. They were performed successfully during the year. In addition, In March 1968, a contract was made with the Japan Radioisotope Association, to treat 3091 disposal bottles in 1968; the sum of contract was $3,976,500. (auth)

**17517** (JAERI-5017, pp 140-2) RADIOACTIVE WASTE TREATMENT AND DECONTAMINATION. (Japan Atomic Energy Research Inst., Tokyo). (In Japanese).

Operational and technical developments in radioactive waste treatment in 1967 consisted of: decontamination of $^{60}Co$ irradiation facilities and irradiation source at the Nagoya Government Industrial Research Institute; reformation of the dust collector of incinerator; and reconstruction of the transporter of animal carcass. (auth)

**17518** (ORNL-4371) PREPARATION OF ENRICHING SALT $^{7}LiF$-$^{233}UF_4$ FOR REFUELING THE MOLTEN SALT REACTOR. Chandler, John M.; Bolt, S. E. (Oak Ridge National Lab., Tenn.). Mar. 1969. Contract W-7405-eng-26. 73p. Dep. CFSTI.

The Molten Salt Reactor has been refueled with an enriching salt concentrate, $^{7}LiF$-$^{233}UF_4$ (73 to 27 mole %). Sixty-three kilograms of this concentrate were prepared in cell G of the Thorium-Uranium Recycle Facility at ORNL. Its preparation in a shielded cell was required because of the high $^{232}U$ content (222 ppM) of the $^{233}U$. In the shakedown run with depleted uranium oxide, a high-temperature, single-step process was used to reduce the oxide and then convert it to $UF_4$ for use in making the eutectic salt. Although this process yielded a high-quality product, severe damage to the equipment was observed. Therefore, it was discarded in favor of a low-temperature, two-step process in which the uranium oxide was reduced to $UO_2$ by treatment with hydrogen, the $UO_2$ was converted to $UF_4$ by hydrofluorination, LiF was added, and the eutectic was formed by fusing the components. The eutectic mixture, LiF-$UF_4$ (73 to 27 mole %), was purified by treatment with hydrogen, which reduced the corrosion products to metal and subsequently allowed their removal by filtration. The quality of the product was well within the requirements established for the MSRE. The fuel concentrate, containing 39.0 kg of uranium (91.4% $^{233}U$), was packaged in nine variable-capacity (0.5 to 7 kg of uranium) shipping containers for addition to the reactor fuel drain tank and in 45 enrichment capsules, each containing 96 g of uranium, for addition to the bowl of the fuel circulating pump. The fuel was shipped in shielded carriers to the MSRE to accommodate the reactor enrichment schedule. (auth)

**17519** (ORNL-TM-2486) SOME ASPECTS OF THE THERMODYNAMICS OF THE EXTRACTION OF URANIUM, THORIUM, AND RARE EARTHS FROM MOLTEN LiF-$BeF_2$ INTO LIQUID Li-Bi SOLUTIONS. Ferris, L. M. (Oak Ridge National Lab., Tenn.). Mar. 1969. Contract W-7405-eng-26. 17p. Dep. CFSTI.

Expressions for the equilibrium distribution of uranium, thorium, lanthanum, and other solutes between LiF-$BeF_2$ solutions and lithium-bismuth solutions at 600 to 700°C were calculated, using thermodynamic data from the literature. The results obtained experimentally for uranium were in reasonably good agreement with the calculated values. However, the results for thorium and lanthanum reflect the high degree of uncertainty that exists in the available thermodynamic data for these solutes. It is concluded, therefore, that an accurate measure of the relative extractability of the various solutes can be obtained only by experimental means. (auth)

**17520** (ORNL-tr-2100) POSSIBILITY OF ISOTOPE SEPARATION OF INTERMEDIATE AND HEAVY ELEMENTS THROUGH CHEMICAL EXCHANGE. Knyazev, D. A.; Ivlev, A. A.; Bantysh, A. N.; Dobizha, E. V. Translated for Oak Ridge National Lab., Tenn., from Kernenergie, 11: 229-38(Sept. 1968). 21p. Dep. CFSTI.

Starting with a quantum-statistical calculation of the fundamental separation factors $\alpha$ and the ratios of the partition functions ($\beta$ factors) as given by Urey, Mayer, and Bigeleisen, the number $\gamma$, which has the function of an efficiency, was derived. The thermodynamic and kinetic properties of the compounds considered are used as criteria to determine whether the exchange system is suitable for industrial processing. The valence, field strength of the components, and the coordination number are first considered as independent parameters. Then the chemical exchange systems are grouped into 7 classes, which allow certain statements to be made on the $\gamma$ value of the system in each case. Each class is illustrated by an example. (auth)

**17521** (UCRL-Trans-10324) IMPROVEMENT OF CHEMICAL SEPARATIONS ON ION EXCHANGE RESINS: EFFECT OF GRAIN SIZE. Aubouin, G.; Laverlochere, J. Translated by R. Dewar for Univ. of California, Lawrence Radiation Lab., Livermore, from J. Radioanal. Chem., 1: 123-37(1968). 24p. Dep. CFSTI.

An abstract of this paper, prepared from the original language, appeared as NSA 22: 40202. (auth)

**17522** (Y-DR-9) CRITICALITY CALCULATIONS FOR LIGHT WATER REACTOR AND LIQUID METAL FAST BREEDER REACTOR FUELS. Magnuson, D. W. (Union Carbide Corp., Oak Ridge, Tenn. Y-12 Plant). [1968]. Contract W-7405-eng-26. 50p. Dep. CFSTI.

Criticality calculations have been performed over the range of moderation to show critical sizes and masses for discharge fuel compositions anticipated in LWR's and LMFBR's. The studies have been directed toward the generation of calculated data for criticality control in preliminary equipment designs for fuel-recycle processing plants. 7 references. (auth)

**17523** $^{13}C$ ENRICHMENT OF METHANE DURING PASSAGE THROUGH ROCKS. Galimov, E. M. (Inst. of Petrochemistry and Gas Production, Moscow). Geochem. Int. (Engl. Transl), 4: 1180-1(1967).

Translated from Geokhimiya, No. 12, 1504-5(1967).

Significant enrichment of $^{13}C$ in methane was measured with increasing distance from the site of input to underground storage in water-bearing Cambrian sand. The enrichment is attributed to preferential bonding of water to the lighter gas. (auth)

**17524** SORPTION OF MOLYBDENUM BY HUMUS PREPARATIONS. Szilagyi, M. (Nuclear Research Inst., Debrecen, Hungary). Geochem. Int. (Engl. Transl.), 4: 1165-7(1967).

Translated from Geokhimiya, No. 12, 1489-92(1967).

The sorption of Mo by a peat fraction enriched in humic acids was studied to determine the role of the organic matter. The pH of the medium and the reducing properties of the humic acids are important in converting the $MoO_4^{2-}$ ion to cationic Mo(V), which can then be sorbed. (auth)

**17525** ASSOCIATION OF RADIUM AND URANIUM WITH PEAT. Titaeva, N. A. (Moscow State Univ.). Geochem. Int. (Engl. Transl.), 4: 1168-74(1967).

Translated from Geokhimiya, No. 12, 1493-9(1967).

Uranium is considerably more mobile than radium in surface waters containing small amounts of calcium bicarbonate. Radium is readily solved by clays as well as by peat. In peat, uranium is bound to the humic and fulvic acids soluble in alkali, whereas the radium is associated with the insoluble residue. Under oxidizing conditions, the elements appear to be retained by ion exchange, but in the presence of high concentrations of calcium in the water, the radium in the peat and in the insoluble residue becomes nearly unexchangeable. The exchangeability of that radium bound to the humic acid is, however, retained. (auth)

**17526** THE THIN-LAYER CHROMATOGRAPHY OF METAL IONS ON CELLULOSE IMPREGNATED WITH PRIMENE JM-T HYDROCHLORIDE. Graham, R. J. T.; Bark, L. S.; Tinsley, D. A. (Univ. of Salford, Eng.). J. Chromatogr., 39: 200-10 (Jan. 28, 1969).

Metal ions were chromatographed on thin layers of cellulose impregnated with the hydrochloride of the long-chain amine Primene JM-T, using hydrochloric acid (1.0 to 9.0 M) as the mobile phase. Many separations are possible at a high impregnation coefficient which are not possible at a low one. The influence of the cellulose, of micellar aggregations of the stationary phase and chloro-complex formation are discussed. (auth)

**17527** HEALTH PHYSICS CONSIDERATIONS IN PROCESSING TRANSPLUTONIUM ELEMENTS. Denham, Dale H. (Battelle-Northwest, Richland, Wash.). Contract AT(45-1)-1830. Health Phys., 16: 475-87 (Apr. 1969).

The radiation hazards of elements 95 through 99 (americium through einsteinium) are compared with $^{239}Pu$. Most of the transplutonic nuclides decay by alpha particle emission and have higher specific activities than $^{239}Pu$. This increased specific activity creates potentially greater contamination control problems, greater alpha–neutron reactions, and more x- and gamma-rays per unit mass than experienced with plutonium. The spontaneous fission half lives of these radionuclides are orders of magnitude shorter than for $^{239}Pu$, leading to prompt fission neutron and gamma exposures not hitherto encountered. Disregarding fluorescent radiation, the combined gamma and neutron dose rate from tens of kilograms of $^{239}Pu$ is equivalent to that from grams of $^{244}Cm$, tenths of $^{241}Am$, and only micrograms of $^{252}Cf$. The transplutonium elements provide a unique combination of hazards—high radiotoxicity, external exposure potential, and criticality—which makes their control a challenge to the practicing health physicist. (auth) (UK)

**17528** SOLVENT EXTRACTION OF HAFNIUM(IV). IX. STABILITY OF HAFNIUM(IV) NITRATOCOMPLEXES AT IONIC STRENGTH OF 4.0 M. Hala, J.; Smola, J. (Univ. of Brno). J. Inorg. Nucl. Chem., 31: 1133-9(Apr. 1969).

Stability constants of hafnium(IV) nitratocomplexes were measured by means of the competitive solvent extraction method at ionic strength of 4.0 M. Corrections were made for the incomplete dissociation of nitric acid. In the range of equilibrium nitrate concentration of 2.0 to 3.8 M the $Hf(NO_3)^{3+}$ and $Hf(NO_3)_2^{2+}$ complexes were identified, with overall stability constants of $\beta_1 = 0.40$ and $\beta_2 = 0.05$, respectively. The stability of the $Hf(NO_3)^{3+}$ complex is discussed with respect to the extraction of the $Hf(TTA)_3NO_3$ mixed complex. (auth) (UK)

**17529** THE AMALGAMATION BEHAVIOR OF HEAVY ELEMENTS. III. EXTRACTION OF RADIUM, LEAD, AND THE ACTINIDES BY SODIUM AMALGAM FROM ACETATE SOLUTIONS. Maly, Jaromir (Univ. of California, Berkeley). J. Inorg. Nucl. Chem., 31: 1007-17(Apr. 1969).

Extraction yields of radium, lead, and the actinides from Ac through No with sodium amalgam from 7M sodium acetate solutions are given. The extraction yield was found to depend upon the amount of HCl added to the sodium acetate solution before extraction. Californium, einsteinium, fermium, mendelevium, radium, and lead were extracted with high yields (75 to 100 percent relative to Cf), while the lower actinides, Ac, Th, Pa, U, Np, Am, Cm, and Bk were extracted with low yield (below 10 percent relative to Cf). The addition of oxidizing agents such as $H_2O_2$ or $HNO_3$ before extraction strongly suppresses the extraction, except in the case of lead. Investigation of the extraction behavior of all actinide elements (except lawrencium, which has no isotopes suitable for conventional chemical study) and a survey of the literature of the extraction behavior of the lanthanides show cases of uncorrelated extraction properties in both series. On the whole, however, high extraction yields correlate with independent evidence for the existence of a dipositive oxidation state in the lanthanides and suggest the possible formation of this oxidation state in californium and heavier actinides. (auth) (UK)

**17530** CHELATE FORMATION AND THE EXTRACTION OF TERVALENT ACTINIUM, AMERICIUM, CURIUM, AND CALIFORNIUM WITH ACETYLACETONE AND ITS DERIVATIVES. Keller, C.; Schreck, H. (Univ., Karlsruhe, Ger. Kernforschungszentrum, Karlsruhe, Ger.). J. Inorg. Nucl. Chem., 31: 1121-32(Apr. 1969). (In German).

It was found that $Ac^{3+}$, $Am^{3+}$, $Cm^{3+}$, and $Cf^{3+}$ with substituted 1,3-diketones $RCOCH_2COR'$ and $CHCl_3$ as organic phase are extracted as 1:3—chelates only, if R = $CF_3$ and R′ is an aromatic group (furyl, thienyl, phenyl, or naphthyl). The distribution coefficient of the chelates is dependent on that of the 1,3-diketone and increases, together with the stability constant $\beta_3$, in the sequence $Ac^{3+}$-$Am^{3+}$-$Cm^{3+}$-$Cf^{3+}$. The $\beta$-isopropyltropolone chelates are much more stable than the acetylacetonates of the corresponding actinides. The enhanced extraction of $Am(TTA)_3$ and $Am(BTA)_3$ in methylisobutylketone (A) is explained by the formation of the adduct-chelates $ML_3 \cdot A$ and $ML_3 \cdot 2A$. The acetylacetone, benzoyl- and thenoyltrifluoracetone chelates of americium were prepared by precipitation reactions. They decompose directly to $AmO_2$ by heating in air. (auth) (UK)

**17531** THE ANION-EXCHANGE ABSORPTION OF AMERICIUM, YTTRIUM, LANTHANUM, EUROPIUM, AND YTTERBIUM FROM AQUEOUS AMMONIUM THIOCYANATE. Coleman, J. S.; Asprey, L. B.; Chisholm, R. C. (Los Alamos Scientific Lab., N. Mex.). J. Inorg. Nucl. Chem., 31: 1167-70(Apr. 1969).

Distribution coefficients are given for anion exchange absorption of trivalent Am, Y, La, Eu, and Yb in 0.5 to 10 M $NH_4SCN$. Effects of loading are shown for absorption of Eu and tracer Am in 6.6 molal $NH_4SCN$ at various $Eu(SCN)_3$ concentrations; distribution coefficients decrease linearly with increasing Eu concentration in the anion exchanger, while the Am–Eu separation factor remains constant. (auth) (UK)

**17532** THE EXTRACTION CHROMATOGRAPHY OF CALIFORNIUM, EINSTEINIUM, AND FERMIUM WITH DI(2-ETHYLHEXYL)ORTHOPHOSPHORIC ACID. Horwitz, E. P.; Bloomquist, C. A. A.; Henderson, D. J. (Argonne National Lab., Ill.). J. Inorg. Nucl. Chem., 31: 1149-66(Apr. 1969).

The extraction chromatography of Cf(III), Es(III), and Fm(III) was studied using di(2-ethylhexyl) orthophosphorate (HDEHP) adsorbed on hydrophobic diatomaceous earth. Dilute nitric and hydrochloric acid solutions were used as the elutriants. Column performance was studied as a function of particle size, capacity, flow rate, and temperature by measuring the number of theoretical plates obtained for Cf(III) and Es(III) elutions. The distribution coefficients of Cf(III), Es(III), and Fm(III), and the separation factors, Es/Cf and Fm/Es, were studied as a function of temperature with HDEHP adsorbed on Celite, using pure undiluted HDEHP, and HDEHP in heptane. The extraction chromatography method was applied to the separation of Es(III) and Fm(III). (auth) (UK)

**17533** A PROPOSED METHOD, USING BACTERIA, FOR THE CONTINUOUS LEACHING OF A URANIUM ORE. McCreedy, H. H.; Harrison, V. F.; Gow, W. A. (Dept. of Energy, Mines, and Resources, Ottawa). Can. Mining Met. Bull., 62: 135-40 (Feb. 1969).

A semicontinuous bench-scale, countercurrent-decantation system, in which the ore was moved countercurrently to the flow of leaching solution, was used to conduct acid-leaching tests on uranium ore with the aid of bacteria. This method, which involved a low degree of agitation, was successfully applied to extract uranium in practical amounts and at practical rates. The acidity

of the leaching solution was the main variable investigated in the bench-scale tests done at the Mines Branch, Ottawa. Over 90 percent of the uranium was extracted in a six-stage system. The results suggest that this technique could be applied in the utilization of bacterial oxidation and leaching as a method for treating Elliot Lake uranium ore. (auth) (Canada)

**17534** VAPOUR PRESSURE OF $H_2{}^{18}O$ ICE. Matsuo, S.; Matsubaya, O. (Tokyo Kyoki Univ.). Nature (London), 221: 463-4(Feb. 1, 1969).

The vapour pressure of $H_2{}^{18}O$ ice was measured in the temperature range from −5 to −20°C in order to determine the fractionation factor of $^{18}O$ between ice and vapour. Experimental details are described. The small difference in vapour pressure between $H_2{}^{18}O$ and $H_2{}^{16}O$ was measured directly by introducing the vapour of the two isotopic species separately to the sides of a U-type manometer. The fractional difference in vapour pressure gave a linear relationship with inverse temperature (°K), from which the vapour pressure of pure $H_2{}^{18}O$ could be calculated. The fractionation factor was calculated, on the assumption of ideal solution, as the ratio of the vapour pressures of pure $H_2{}^{18}O$ and $H_2{}^{16}O$. Results are tabulated, and sources of error are indicated. (UK)

**17535** THE LABORATORY FOR INDUSTRIAL DEVELOPMENT AT EUROCHEMIC: ITS MISSIONS AND WORKING AREAS. Schmid, E. (Eurochemic, Geel, Belg.). Chem. Ztg., 92: 769-74(Nov. 5, 1968). (In German).

The establishment of Eurochemic had as its purpose the foundation of a research laboratory for the study and a plant for the preparation of reactor elements. An important goal is the automation of production processes; continuous monitoring of the Purex process for U and Pu is being developed. The method chosen for monitoring U by x-ray fluorescence is defended on practical grounds. Problems of the disposal of radioactive wastes are also studied, with emphasis on the NSS (neutralization-self-solidification) process. The production of U(IV) is also studied. The recovery of side products, especially $^{237}Np$, is a further goal. Studies of the oxidation states of Np and Pu are being made with an eye to finding convenient methods for achieving proper states for extraction cycles easily. Inflow and outflow analysis of impurities is reviewed. Solvent stability to radiation is likewise a subject of study. (BBB)

**17536** STATE OF Pa(V) IONS IN HALOGEN ACID SOLUTIONS. Davydov, A. V.; Pal'shin, E. S.; Palei, P. N.; Pribylova, G. A. At. Energ. (USSR), 25: 493-9(1968). (In Russian).

The extraction of protactinium, niobium, and zirconium using a tetraphenylphosphonium chloride solution in chloroform, the sorption of the mentioned elements by the cationite Dowex-50 and the anionite AB-17, and the electrophoresis on paper of Pa(V) ions in haloid acid solutions were studied. In hydrofluoric acid solutions Pa(V) formed stable fluoride anionic complexes over a large acid concentration range which could not be extracted by the tetraphenylphosphonium cation. In HCl, HBr, and HI solutions protactinium formed anionic complexes. The charges of these complex ions were determined. A comparison of the extraction and ion-exchange behavior of protactinium, niobium, and zirconium showed that protactinium, by its ability for complexing with halide ions (except $F^-$), is nearer to zirconium than to niobium. (auth)

**17537** ISOLATION OF PLUTONIUM IN CHLORIDE MEDIA. I. ANION EXCHANGE RESIN STUDIES. Chilton, J. M. (Oak Ridge National Lab., Tenn); Fardy, J. J. J. Inorg. Nucl. Chem., 31: 1171-7(Apr. 1969).

Anion exchange resins were used to separate and purify plutonium from transplutonium elements in hydrochloric acid solutions. Using glove-box runs to evaluate the many variables, a separation procedure was developed that can be used for laboratory- or large-scale separations. Although the method proved satisfactory for processing multigram quantities of plutonium in all-glass equipment, difficulty in holding the plutonium in the correct valence state may occur when the purification is performed in certain types of metal equipment. Results concerning the effects of many of the variables are presented and evaluated. (auth) (UK)

**17538** STUDY OF THE POSSIBLE CONTROL OF $^{234}U$ AND $^{238}U$ ATOM SEPARATION BY THE WAY OF AN EXTERNAL OXIDATION OF URANIUM CONTAINED IN NATURAL COMPOUNDS. Chalov, P. I.; Merkulova, K. I. (Inst. of Physics and Mathematics, Frunze, USSR). Geokhimiya, No. 2, 225-8(Feb. 1969). (In Russian).

The isotopes $^{234}U$ and $^{238}U$ may be partially separated by isolating the valence fractions resulting from the difference in oxidation rates of these isotopes contained in natural uranium compounds. An attempt was made to increase the degree of separation by subjecting the uranium in minerals to an external oxidation process. Experiments included the determination of $^{234}U/^{238}U$ ratio = $\gamma$, in activity units, in tetravalent and hexavalent uranium, designated as $\gamma_4$ and $\gamma_6$, respectively, and in material leached from the rock, $\gamma_L$. The spectrometrically determined $\gamma$ values indicated that the pitchblende specimen had a total uranium content of 37.9%, with $U^{6+}/U^{4+}$ ratio of 0.17 before oxidation with oxygen. The isotopic ratio of uranium had the equilibrium value, $\gamma_E = 1$, but in the hexavalent and tetravalent factions it differed strongly: $\gamma_6/\gamma_4 = 1.11$. It was concluded that the degree of separation of the two isotopes may be strongly affected by separating the uranium into fraction with different valence states. The maximum possible separation depends on the differential oxidation rates of $^{234}U$ and $^{238}U$. (TTT)

**17539** SEPARATION AND PURIFICATION OF RARE EARTH ELEMENTS BY VACUUM DISTILLATION. Trombe, Felix; Male, Germain (CNRS, Bellevue, France). Rev. Int. Hautes Temp. Refract., 5: 287-94(Oct.-Dec. 1968). (In French).

A theoretical study was made of liquid-vapor equilibriums in ideal solutions. Experimental data, which exist for rare earths and their impurities, especially vapor pressure, are reviewed. Definitions of the possible separations and the final purity reached in different cases are given. Various experimental studies with distillation in an electron-beam furnace are described along with the separation La-Fe and testing in the La-Nb segregation. (auth)

**17540** SEPARATION OF NUCLEAR ISOMERS OF TELLURIUM USING ITS ELEMENTARY ORGANIC DERIVATIVES. Sinotova, E. N.; Timofeev, S. A. Radiokhimiya, 10: 756-8(1968). (In Russian).

A method was developed for separating the nuclear isomers of tellurium by thin-layer partition chromatography. The compound $(C_6H_5)_2Te$, prepared by heating diphenylmercury with metallic, radioactive tellurium, was used as the starting material. Because of its high conversion coefficient, $-\alpha = 0.98$,- and convenient half-lives, the isomeric pair $^{127m}Te$ and $^{127}Te$ was chosen for the experiment. As a result of internal conversions, most of the $^{127}Te$ is present in its simplest inorganic form in the diphenyltelluride, making it possible to separate it from the original organic compound. Petroleum ether and $Al_2O_3$ were used as the eluent and the sorbent in the thin-layer chromatography. The half-life of Te in its ground state, as determined from activity measurements as a function of time, was found to be 9.7 hours, indicating the high purity of the separated isomers; a similar conclusion was reached from the value of $\tau_{max} = 75$ hours (establishment of the equilibrium), which agrees with the calculated value of 76 hours. It was concluded that the thin-layer chromatography offers a highly efficient separation method. (TTT)

**17541** REACTOR AND FUEL-PROCESSING TECHNOLOGY. VOLUME 11, NUMBER 4. One of the Four Technical Progress Reviews Published for the Division of Technical Information, USAEC. Argonne, Ill., Argonne National Lab., Fall 1968. 68p. GPO $0.70.

Eight papers are included; separate abstracts were prepared for each. (P.C.H.)

*For abstracts of individual papers see: 17542–17545, 19479, 19515, 19543, and 19559.*

**17542** PROGRESS IN RESEARCH AND DEVELOPMENT ON WASTE DISPOSAL. Fineman, Phillip. Reactor Fuel-Process. Technol., 11: 227-31(Fall 1968).

Developments in methods for conversion of high-level-activity wastes to solids are reported. These methods consist of: fluid-bed calcination; pot calcination; and conversion to glass. Selected current literature on waste disposal is also given. (P.C.H.)

**17543** COMPACT PYROCHEMICAL PROCESSES. Miller, W. E.; Steunenberg, R. K. Reactor Fuel-Process. Technol., 11: 219-26(Fall 1968).

Pyrochemical-processing development work concerned with the processing of fast breeder reactor fuel and molten-salt breeder reactor fuel are discussed. Special attention is given to the salt-transport process for fast breeder reactor fuels. (P.C.H.)

**17544** VOLATILITY PROCESSES. Vogel, G. J.; Simmons, J. W. Reactor Fuel-Process. Technol., 11: 209-18(Fall 1968).

Fluid-bed fluoride-volatility processes including chemical removal of cladding, oxidation of the ceramic oxide to a fine powder, fluorination to form volatile actinide hexafluorides, and purification of hexafluorides prior to their conversion to oxide for recycle to the reactor are discussed. Development work at the Oak Ridge Gaseous Diffusion Plant (ORGDP), Oak Ridge National Laboratory (ORNL), Centre d'Etude de l'Energie Nucleaire (Mol, Belgium), Argonne National Laboratory (ANL), Battelle Memorial Institute, and Fontenay-aux-Roses is reviewed, since different sites are using different fluorination agents (F, $BrF_5$, $ClF_3$, and ClF). (P.C.H.)

**17545** RESEARCH AND DEVELOPMENT ON AQUEOUS PROCESSING. Stevenson, C. E.; Paige, D. M. Reactor Fuel-Process. Technol., 11: 201-8(Fall 1968).

Various process methods and design and operation of plant and equipment for processing reactor fuels are discussed. The process methods include: effects of Si on reprocessing of Al–U alloy fuels; aqueous processing of EBR-II fuel; corrosion in processing zirconium-type fuels with HF; recovery of Am and Cm from Shippingport reactor fuel; Np–Pu recovery from Purex waste; and deterioration of extraction solvents under irradiation. The results of Eurochemic plant operation are also reported. (P.C.H.)

**17546** CHROMATOGRAPHIC BEHAVIOR OF METAL IONS ON PAPER TREATED WITH PHOSPHORIC ESTERS. UTILIZATION OF TRIALLYL PHOSPHATE FOR THE SEPARATION OF THE MIXTURE: $UO_2^{2+}$, $Cu^{2+}$, AND $Fe^{3+}$. Liteanu, C.; Ungureanu, Ana (Inst. of Chemistry, Cluj). Rev. Roum. Chim., 13: 899-903(July 1968).

The chromatographic behavior of the metallic ions $UO_2^{2+}$, $Cu^{2+}$, and $Fe^{3+}$, on paper impregnated with triallyl phosphate, was investigated. Hydrochloric, nitric, and sulfuric acid in different concentrations were used as elution agents. The $R_f$ values, which show the possibility of separation of the investigated ions, are given as functions of the acid concentration. The relationship between $R_f$ values and the properties of the triallyl phosphate as an extractant is shown. (auth)

**17547** THE DESORPTION OF TRACES OF $^{144}Ce$ FROM COTTON FABRIC IN PHOSPHATE SOLUTIONS OF DIFFERENT AGE. Hala, Miloslav; Bar, Jaromir (Antonin Zapotocky's Military Academy, Brno). Jad. Energ., 15: 92-4(Mar. 1969). (In Czech).

The experimental investigation of the desorption of $^{144}Ce$ traces from cotton fabric in sodium polyphosphate (the so-called "hexametaphosphate"), pyrophosphate and orthophosphate solutions and their mixtures in the dependence on the age of the desorption solutions indicated the considerable desorption effect of polyphosphate and pyrophosphate solutions to be only little changed with the age and the relatively poor desorption effect of orthophosphate solutions to be considerably changed. (auth)

**17548** SEPARATION OF RHENIUM FROM MOLYBDENUM, TUNGSTEN, CHROMIUM, VANADIUM, SELENIUM, TELLURIUM, AND OSMIUM BY EXTRACTION WITH ACETYLACETONE FROM ALKALINE SOLUTION. Yatirajam, V.; Kakkar, L. R. (Kurukshetra Univ., Haryana, India). Anal. Chim. Acta, 44: 468-71(Feb. 1969).

The separation of rhenium from molybdenum can be achieved by simple extraction with acetylacetone from slightly alkaline solution followed by removal of the co-extracted molybdenum traces by the xanthate method. The method also separated Re from V(V), Cr(VI), W(VI), Se(VI), Te(VI), and Os(VIII). (D.H.M.)

**17549** THE SEPARATION OF IRON FROM RUTHENIUM BY ISOPROPYL ETHER EXTRACTION. Potts, Lawrence W.; Lingane, Peter James (Univ. of Minnesota, Minneapolis). Anal. Chim. Acta, 44: 460-1(Feb. 1969).

In the dissolution of ruthenium metal by alkaline peroxide or alkaline nitrate fusion in an iron crucible, the fluxes attack the walls of the crucible and a considerable amount of the iron is dissolved. A method for separating the Fe from the extraction into isopropyl ether is presented. It was found that neither Ru(III) nor Ru(IV) is appreciably extracted by isopropyl ether. (D.H.M)

# EARTH SCIENCES

## Geology and Hydrology

*Refer also to abstracts 17523, 17631, 17812, and 17998.*

**17550** (AEC-tr-7030, pp 14-25) DIFFUSION OF $^{90}Sr$ IN SOILS. Polyakov, Yu. A.; Gol'tsov, V. F.; Grakovskii, V. G. Translation of report A-AC-82/G/L-1242.

The diffusion of $^{90}Sr$ was studied in several varieties of black earth and forested-steppe soils found within the arid steppe zone of Russia. Both field and laboratory observations were made. The physicochemical properties of these soils which were determined included the organic content, the pH of aqueous suspension, absorption capacity, and the composition of the absorbed bases. The laboratory methods used and the theoretical method for computing soil diffusion characteristics based on Fink's equation are explained. The $^{90}Sr$ studies showed that: the diffusion coefficients for the soils studied ranged from $0.6 \times 10^{-7}$ to $20 \times 10^{-7}$ $cm^2/sec$ depending on the properties of the soil; the diffusion coefficient was constant only for homogeneously prepared soil samples, and, under natural soil conditions, the diffusion coefficient must be considered as variable; and, the methods developed for preparing soil samples and for solving Fink's equation could be used for studying the diffusion of ions other than $^{90}Sr$. (L.C.L.)

**17551** (AEC-tr-7030, pp 106-18) EXPONENTIAL SOURCE AS A MODEL OF RADIOACTIVE CONTAMINANTS. Pavlov, V. V.; Konstantinov, I. E.; Fedorov, G. A. Translation of report A-AC-82/G/L-1250.

A description is given of the use of three-dimensional mathematical models for estimating dose rates from radioactive substances in lower layers of soils based on the experimentally determined distribution of radioactive material in soil according to the relationship $q = q_0 e^{-kz}$, where q(z) is the volume density of the concentration of a radioactive isotope at depth z; and k is the constant of distribution of sources in the soil. The magnitude of k depends quite largely upon the type of soil and the age of the radioactive fallout. The method of computing the dose rate is illustrated, and the results plotted. (L.C.L.)

**17552** (AEC-tr-7030, pp 134-44) METHODS OF STUDYING THE BEHAVIOR OF RADIOSTRONTIUM IN SOILS OF DIFFERENT GEOCHEMICAL REGIONS. Tyuryukanova, E. B. Translation of report A-AC-82/G/L-1253.

The behavior of $^{90}Sr$ in soils of different regions is determined by many factors including: the place where it is produced; the manner and rate of entry; and the nature of the topographic-geochemical situation into which the isotope enters. Methods for evaluating the effects of these variables are presented. It is concluded that topographic-geochemical studies must precede any forecasting of the radiation situation for a particular locality, especially the distribution, migration, and formation of secondary foci of $^{90}Sr$ accumulation. (L.C.L.)

**17553** (AEC-tr-7030, pp 145-8) CHARACTER OF THE VERTICAL DISTRIBUTION OF $^{137}Cs$ IN SOIL IN CERTAIN AREAS OF THE SOVIET UNION, 1966-1967. Fedorov, G. A.; Konstantinov, I. E.; Rumyantsev, A. D.; Brendakov, V. F. Translation of report A-AC-82/G/L-1256.

The vertical distribution of $^{137}Cs$ in soil at four sites in the USSR was measured in 1966 and 1967 and compared with similar data acquired before 1961. The sampling and measurement procedures are described. The results indicate that $^{137}Cs$ activity decreases more rapidly with depth than does $^{90}Sr$ activity and is practically all concentrated in an upper layer 2 cm deep. 42 to 82% of all the $^{137}Cs$ activity, including that in the plant cover, was at a depth less than 6 mm. The relaxation lengths for $^{137}Cs$ in soil exceeded those observed before the 1961 to 1962 tests, and can be explained by the fact that the powerful 1961 and 1962 tests resulted in fallout deposition during 1963 to 1965 and by assuming that the $^{137}Cs$ deposited in 1966, unlike that produced in tests up to 1959, had not had time to migrate appreciably into the soil. Further studies of this time dependence factor and of the effects of other soil types is recommended. (L.C.L.)

**17554** (AEC-tr-7030, pp 152-6) VERTICAL DISTRIBUTION AND EVALUATION OF THE MOBILITY OF FISSION PRODUCTS IN CERTAIN SOIL TYPES OF THE SOVIET UNION. Brendakov, V. F.; Svishcheva, V. I.; Dibtseva, A. V.; Churkin, V. N. Translation of report A-AC-82/G/L-1258.

Samples of two types of undisturbed Russian soil, in 3 mm thick layers, were collected and examined during 1963 to 1966 to determine the vertical distribution and mobility of the following fission products: $^{144}Ce$, $^{137}Cs$, $^{106}Ru$, $^{125}Sb$, and $^{90}Sr$. The results showed over 76% of all the radioisotopes were in the top 20 mm soil layer with only traces below a depth of 150 mm, and that the transfer of the bulk of the radioisotopes did not exceed a few mm per year. (L.C.L.)

**17555** (TID-24985) LITHOLOGIC LOG OF EMPLACEMENT DRILL HOLE UA-1 FROM 5,000 TO 6,500 FEET, AMCHITKA ISLAND, ALASKA. Amchitka 6-3. Lee, William H. (Geological Survey, Denver, Colo.). Feb. 14, 1969. Contract AT(29-2)-474. 5p. (USGS-474-4). Dep. CFSTI.

Emplacement drill hole UA-1, located at Site C, was continuously cored in a center-punched hole from 5,020 to 6,500 feet. The center-punch hole was entirely within the older breccias and basalts. Units within the interval penetrated by the center-punch hole are generally 30 to 50 feet lower than comparable units in drill hole UAe-1, 300 feet to the southwest. (auth)

**17556** (TID-24986) SOME PHYSICAL PROPERTIES OF ROCKS IN DRILL HOLE UAe-2, AMCHITKA ISLAND, ALASKA. Amchitka 10-2. Lee, William H. (Geological Survey, Denver, Colo.). Feb. 15, 1969. Contract AT(29-2)-474. 14p. (USGS-474-5). Dep. CFSTI.

Physical properties of rocks from drill hole UAe-2 are analyzed by averaging and minimum-maximum ranging. Data source for the analysis is Birdwell 3-D log computations. Laboratory determinations are presented in table form. Rocks in the drill hole were divided into 12 separate lithologic types for purposes of analysis. The physical properties of similar lithologic types are compared and the conclusion is drawn that alteration significantly changes the properties of the rock. (auth)

**17557** (TID-24987) SUMMARY GEOLOGIC REPORT ON THE U20e EMPLACEMENT HOLE, PAHUTE MESA, NEVADA TEST SITE. Special Studies-25, Supplement 2. Sargent, K. A. (Geological Survey, Denver, Colo.). Feb. 24, 1969. Contract AT(29-2)-474. 6p. (USGS-474-8(Suppl.2)). Dep. CFSTI.

Emplacement hole U20e, in Area 20, Pahute Mesa, Nevada Test Site, has a total depth of 3,853 feet. Stratigraphic units correlate very closely with those in UE20e-1, approximately 1,500 feet to the north-east. (auth)

**17558** (UCRL-50573) ON THE STATISTICAL INTERPRETATION OF LABORATORY TESTS ON ROCK. Robinson, E. Y.; Finnie, I. (California Univ., Livermore. Lawrence Radiation Lab.). Jan. 15, 1969. 26p. Dep. CFSTI.

The statistical flaw theory of brittle failure, usually in the form of a Weibull Distribution, has been used to explain such features as variability and size effect. Following a brief review of extreme value statistics and the Weibull Distribution, new working charts are presented which are of value in estimating the Weibull Modulus (shape factor) for an observed sample, and allow convenient and rapid plotting of a selected distribution. The uncertainty in Weibull Modulus estimates is discussed in connection with sample size specification. The flaw theory, in addition to giving a basis for strength distribution, may be applied to the statistical question of fracture-source location. Such analysis provides a new basis for assessing the applicability of the extreme flaw theory to a material under investigation. The method is used here to check influences of test apparatus, which may disturb the expected fracture-source distribution, and also to confirm estimates of the Weibull Modulus arrived at by other means. Flexure and compression data for two granitic rocks are presented to demonstrate the application of these principles, and to show a relation between the statistical distribution of strength and the size effect. While the application of extreme-flaw theory is fairly satisfactory in cases where significant tensile stresses are induced, the important question in rock mechanics is behavior under compression. There are a number of cases in which the statistical behavior in compression and tension are comparable, e.g., similar coefficients of variation and similar distribution shapes, although the nominal uniaxial compressive strength may be 5 to 30 times greater. The statistical similarity suggests that similar flaws are strength-controlling, but the widely differing strength values must be accounted for. A tentative step in this direction is made by proposing, as a greatly simplified model, the tensile failure of a plate with a circular hole subject to nominal uniaxial tension and compression. This macroscopic flaw model, coupled with the statistical microscopic extreme-flaw theory, predicts widely different axial strengths while maintaining statistical similarity. (auth)

**17559** INFLUENCE OF RARE EARTHS ON NEUTRON MOISTURE MEASURING. Kasi, Servo (Technical Univ., Helsinki). Nucl. Eng. Design, 8: 317-20(Sept.-Oct. 1968).

The influence on the neutron moisture measurement of the elements having especially strong thermal absorption properties has been calculated. It has been found that such elements as boron and rare earths, mainly gadolinium and samarium, have a significant disturbing effect on this measurement when thermal detection is used. The change in the thermal neutron flux caused by the average abundance of gadolinium in the earth's crust is some times larger than the corresponding change due to boron. The influence of all these elements is negligible, however, when epithermal detection is used. (auth)

**17560** DETERMINATION IN SITU OF SOIL PERMEABILITY BY PUNCTUAL DILUTION METHOD. Bisir, Dumitru; Gaspar, Emilian. Hidroteh. Gospod. Apelor, Meteorol. (Bucharest), 12: 305-14(June 1967). (In Rumanian).

Results of soil research performed by means of nuclear methods for determining the permeability of soils in saturated and unsaturated zones are presented. Results are critically evaluated in comparison with the data obtained by hydrogeological determinations performed on the same soils in the same period of time. (Meteorol. Geoastrophys. Abstr.)

**17561** THE USE OF $^{18}O$ AND DEUTERIUM CONCENTRATIONS IN THE WATER BALANCE OF LAKES. Dincer, T. (International Atomic Energy Agency, Vienna). Water Resour. Res., 4: 1289-1305(Dec. 1968).

It was shown that the deuterium and $^{18}O$ content of lake waters can be used in determining the water balance of lakes where some components of the water balance are not well known. Such situations are common in lakes formed or in reservoirs established in fractured rocks, especially in karst regions where losses are likely to occur and are difficult to estimate quantitatively. Natural concentrations of the stable isotopes of hydrogen and oxygen were used to determine the water balance of lakes situated in a subhumid climate in southwestern Turkey. A salt lake in that region was used as an index to the molecular exchange process between the lake and the atmospheric moisture. Such use of stable isotopes of oxygen and hydrogen in water balance studies appeared to yield promising results and indicated that environmental isotopic studies might be a useful tool in limnological studies. As in all hydrologic investigations, an adequate sampling for precipitation, runoff, and lake waters, together with other meteorological factors such as atmospheric temperature and humidity, is of primary importance in obtaining conclusive results. (BBB)

**17562** NATURAL RADIOACTIVITY OF ROCKS IN THE MOLODEZHNAYA STATION. Senin, E. V. Sov. Antarct. Exped. Inform. Bull. (Engl. Transl.), 6: 571-3(Sept. 1968).

Rock outcrops in the Molodezhnaya Station area, mainly gneisses, pegmatite granites, and occasionally mica, were assayed. The presence of acid rocks, containing a relatively large amount of radioactive elements, explains the enhanced background level in this area. The absolute activity of the rocks is tabulated. The main radioactive elements are probably $^{238}U$ and $^{232}Th$ with their decay products, as well as $^{40}K$ and $^{87}Rb$. The activity of other elements, such as $^{124}Sb$ and $^{138}La$, is several orders of magnitude lower than that of the main elements. Enhanced radioactivity was observed in areas with red granites. Gray granites had a lower specific $\beta$ activity. The reason for this is the increased content of $^{40}K$ and $^{87}Rb$ in red granites. Measurements were also made of $\gamma$ radiation by means of a portable radiometer with a counter shielded from $\beta$ radiation. The measurements were made 1 m above the ground surface and the normal radiometer background was taken as 5 mCi/hr. Results showed that the $\gamma$ radiation dose in the Molodezhnaya area varies substantially because of the reduction of radiation by the snow cover. On a dome (100 m above sea level) the dose from the ground surface is practically zero. (BBB)

**17563** MOVEMENT OF ALGAL- AND FUNGAL-BOUND RADIOSTRONTIUM AS CHELATE COMPLEXES IN A CALCAREOUS SOIL. Fuller, Wallace H.; L'Annunziata, Michael F. (Univ. of Arizona, Tucson). Contract AT(11-1)-947. Soil Sci., 107: 223-30(Mar. 1969).

Leaching with a water-formaldehyde solution and water alone caused little movement of radiostrontium in Mohave sandy loam. Leachings with 0.067 M DPTA solutions displaced from 0.2 to 1.6 per cent of the algal- and fungal-bound radiostrontium below a 20-cm depth. The profile distribution of radiostrontium remaining in the leached soil columns was strikingly contrasted between the DTPA-treated and the $H_2O$-treated columns. Wherever DTPA was added, the radiostrontium moved downward throughout the column, whereas in the $H_2O$-treated control soils, the radioactivity remained primarily in the upper 2.5 cm layer where it was applied. Evidence is given for the presence of negatively charged radiostrontium complexes formed from excretions of the desert soil alga Anacystis Menegh. (auth)

**17564** THE FIXATION AND PLANT RECOVERY OF $^{137}Cs$. Evans, E. J.; Dekker, A. J. (Canada Dept. of Agriculture, Ottawa). Soil Sci., 107: 175-80(Mar. 1969).

$^{137}Cs$ fixed against extraction by neutral N ammonium acetate was found to increase on moist incubation in two acid soils either when heavily precropped to oats or when not precropped. These results were not in agreement with the work of others but the difference can probably be attributed to the differences in the soils used. Fixation was greater in the precropped soils than in the soils not precropped. Both soils fixed more $^{137}Cs$ when cropped to alfalfa than when left uncropped, in agreement with other investigations, but the differences in $^{137}Cs$ fixed between the precropped and the not precropped condition were eliminated when the soils were further cropped to alfalfa. The previous cropping conditions appear to be unimportant to $^{137}Cs$ fixed during subsequent cropping. When the effects of $^{137}Cs$ fixation by certain environmental factors were investigated, it was found that the two soils differed in several respects. The one fact which was the same for all soil conditions was that alternate wetting and drying of the soils fixed more $^{137}Cs$ than did moist incubation or dry incubation at 0°, 36°, and 75°F, respectively. $NH_4Cl$ and KCl leached much more $^{137}Cs$ from the soils than did $MgCl_2$, $CaCl_2$ or $AlCl_3$, yet appreciable $^{137}Cs$ was taken up by oats from the $^{137}Cs$ remaining in the soil after being leached by $NH_4Cl$ and KCl. This tended to show that soluble $^{137}Cs$ added to soil but fixed against extraction by salts was available to plants and that the ammonium ion caused greater amounts of $^{137}Cs$ to be taken up by the plant than did other ions. (auth)

**17565** BEHAVIOR OF THE U–Th–Pb SYSTEMS IN THE UPPER MANTLE AND MODEL OF EVOLUTION OF THE LATTER DURING THE COURSE OF GEOLOGIC TIMES. Allegre, Claude J. (Faculte des Sciences, Paris). Earth Planet. Sci. Lett., 5: 261-9(Dec. 1968). (In French).

Using the generalized Concordia diagram, a behavior's examination was made of the U–Th–Pb system in the upper mantle. A continuous volcanism eruption model was developed. In this model the cogenetic relation among several suites of volcanic rocks is demonstrated. The age of the Earth is also examined and the initial value for $\mu$ and Th/U was calculated. (auth)

**17566** LEAD ISOTOPE STUDIES ON IGNEOUS ROCKS FROM THE ISLE OF SKYE, NORTHWEST SCOTLAND. Moorbath, S.; Welke, H. (Oxford Univ.). Earth Planet. Sci. Lett., 5: 217-30 (Dec. 1968).

Lead isotope ratios, together with uranium and lead analyses, are reported for Lower Tertiary (ca. 55 to 60 my) igneous rocks from Skye. Rocks analyzed include ultrabasic, basic, intermediate and acid types. The leads from all these rocks are isotopically anomalous ("B"-type) when interpreted by a conventional single stage lead evolution model. All the leads fall on an anomalous $^{206}Pb/^{204}Pb$ versus $^{207}Pb/^{204}Pb$ lead line, which cuts a conventional growth curve (with $^{238}U/^{204}Pb = 8.92$ (at $t_1 = 3100$ my and $t_2 = 60$ my. Each lead is therefore regarded as a mixture of ancient, crustal lead, derived from the underlying Lewisian basement rocks, with relatively young, upper mantle lead. The proportion and absolute amount of each type of lead within a given rock may be calculated from the anomalous lead line, when taken in conjunction with other isotopic and geochemical data. Analogous calculations are also possible on the basis of the observed $^{208}Pb/^{204}Pb$ ratios. In general, the acid rocks contain much larger absolute amounts of crustal lead than the basic and ultrabasic ones. Uranium and lead contents, as well as uranium/lead ratios in the Skye acid igneous rocks are found to be much closer to the values for average Lewisian basement gneisses in the vicinity of Skye than to the values for acid igneous rocks of a truly oceanic area such as Iceland. The percentage of ancient, crustal lead in the Skye rocks (between ca. 10 to 80%) cannot possibly represent the same percentage of bulk contamination with, or assimilation of, country rock. While the basic and ultrabasic rocks have been probably contaminated with small absolute amounts of ancient crustal lead, the most likely mechanism to account for the origin of the acid rocks, taking all available evidence into account, is a combination of partial melting of the underlying Lewisian gneisses with differentiation of a smaller amount of acid material from the large basic masses which underlie the Skye acid igneous centers, followed by localized hybridization of pockets of anatectic and differentiated acid magmas and localized isotopic homogenization. (auth)

**17567** THE ISOTOPIC COMPOSITION OF LEAD FROM ST. HELENA AND ASCENSION ISLANDS. Gast, Paul W. (Columbia Univ., Palisades, N. Y.). Earth Planet. Sci. Lett., 5: 353-9 (Jan. 1969).

The isotopic compositions of lead from 7 volcanic rocks from St. Helena and 7 volcanic rocks from Ascension Island are presented. The St. Helena leads are the most radiogenic volcanic lead samples analyzed to date. A graphic presentation relating the parameters $\mu_1$, $\mu_2$ and $T_1$ for a two-stage lead evolution model is given. It is suggested that both the U/Pb ratio and Th/U ratio of the upper mantle source of the St. Helena volcanic rocks were fractionated prior to several hundred my ago. (auth)

**17568** ISOTOPIC COMPOSITION OF HELIUM AND ARGON FROM MICROINCLUSIONS IN RISTSCHORRITE. Prasolov, E. M.; Tolstikhin, I. N. (All-Union Geological Oil-Prospecting Inst., Leningrad. Inst. of Geology and Geochronology of the Precambrian, Leningrad). Geokhimiya, No. 2, 231-4(Feb. 1969). (In Russian).

The isotopic composition of microinclusions in ristschorrite samples from the Khibin Massif was determined, using 2 to 4 mm diameter rock specimens which were ground under high vacuum. The $^3He$, $^4He$, $^{40}Ar$ and $^{36}Ar$ content of the gas released after grinding and melting was determined by means of a magnetic resonance mass spectrometer designed for measuring $^3He/^4He$ of 2 to $3 \times 10^{-8}$. The instrument had a sufficiently high resolution to identify the $^3He$, HD and $^4He$ lines. A British MS10 type mass spectrometer was used for the isotopic analysis of argon; the high vacuum of about $10^{-9}$ torr made it possible to keep low the atmospheric argon background. The amount of $^{36}Ar$ in the microinclusions was found to increase directly with the weight of the sample; thus it was not due to the background. The results indicated that the $^{36}Ar$ is released at <800°C, while $^{40}Ar$ is retained in the crystal lattice until >1000°C. Three hypotheses were advanced to explain the origin of $^{36}Ar$. The calculations indicated that an error of about 10% is committed in the age determination if the argon is not taken into account; dating on the basis of the (U + Th)/He ratio may differ by about 50%. Thus dating errors may be especially large for rocks which contain small amounts of radioelements with large amounts of captured argon and helium. (TTT)

**17569** RELATIVE ADSORPTION AND DESORPTION OF STRONTIUM AND CALCIUM TO AND FROM SOILS AND SOIL CLAYS: COLUMN SATURATION-DISPLACEMENT AND ACID DISPLACEMENT. McLean, E. O.; Lakshmanan, C.; Miller, F. P. (Ohio State Univ., Columbus. Ohio Agricultural Research and Development Center, Columbus). Soil Sci., 107: 206-12(Mar. 1969).

Samples from a Canfield soil were column leached with mixed $CaCl_2$-$SrCl_2$ solutions. Samples were also leached with $AlCl_3$ or HCl solutions, dried, and column leached. Aliquots of the acid-leached soils were limed at various rates, incubated, dried and column leached. Clay fractions were separated, saturated with Ca and Sr, and equilibrated with 0.5 symmetry of HCl. Column leaching indicated marked preferential adsorption of the Ca sample, small preferential Sr adsorption, and equal adsorption of Ca and Sr. Adsorption of Ca and Sr suggested that the main effect of acid leaching was to inactivate organic charges for adsorption of Ca and Sr, thus eliminating preferential adsorption of Ca. Amounts of Ca and Sr in solution after equilibration of Ca-Sr-clays indicated that small preferential adsorption of either cation may occur, but on the average there is a slight preferential adsorption of Sr. Additions of lime and incubation of the acid-leached soils reestablished the preferential adsorption of Ca. Moist incubation conditions evidently favored reactivation of Ca-preferring organic sites. Greater adsorption of Ca to hydrolysis-enhancing, pH-dependent organic exchange sites may account for greater plant uptake of Ca than Sr from soils. Greater leaching of $^{90}Sr$ from unlimed soil appears to be a consequence of its displacement by additional electrolyte per effective charge, due to lower cation exchange capacity at low pH. (auth)

**17570** CONTENT OF RADIOACTIVE ELEMENTS OF SOME ROCKS OF THE VOSGES. Mathevon, Gilbert; Rothe, Jean-Pierre (Institut de Physique du Globe, Strasbourg). Compt. Rend., Ser. D, 267: 2276-9(Dec. 23, 1968). (In French).

The content of Ra, Th, U, and K measured in the laboratory confirm the measurements of the total effective radiation on the ground. The large petrographic units which appear on the cards can also be characterized by their content of Th and U. (tr-auth)

## Meteorology

*Refer also to abstracts 17626, 18019, and 19608.*

**17571** (AEC-tr-7030, pp 65-74) $^{90}Sr$ AND $^{137}Cs$ IN CERTAIN PARTS OF THE EXTERNAL ENVIRONMENT AND IN THE HUMAN BODY, 1958-1967. Zykova, A. S.; Telushkina, E. L.; Rublevskii, V. P.; Ephremova, G. P.; Kuznetsova, G. A. Translation of report A-AC-82/G/L-1248.

Ten years of observations carried out in Moscow on the radioisotope content of air, certain foods, ground-level fallout and infants' bones are summarized. It was established that from 1958 to 1967, 52 mCi/km$^2$ of $^{137}Cs$ and 33 mCi/km$^2$ of $^{90}Sr$ were deposited on the surface of the earth in the Moscow area. The highest values for radioactive substances were observed during 1962 to 1963. When the 1967 measurements were compared with data from 1962 to 1963, it was found that the $^{137}Cs$ and $^{90}Sr$ content of milk decreased by factors of 13.3 to 14.3; of ground-level fallout by factors of 7.7 to 8.1; and of milk by factors of 7.6 and 3.0, respectively. The half-removal time of $^{137}Cs$ and $^{90}Sr$ aerosols from the lower stratosphere was 1.5 years. Observations in 1965 to 1967 satisfactorily confirm the relation established earlier between the $^{137}Cs$ and $^{90}Sr$ contents of air and ground surfaces, ground surfaces and milk, and milk and children's bones. The $^{137}Cs/^{90}Sr$ ratio in air, surface fallout and milk is not the same. This ratio was the lowest in air and fluctuated in various years from 1.0 to 1.6; in surface fallout from 1.2 to 2.0; and in milk from 2.0 to 9.2. (L.C.L.)

**17572** (CEA-R-3614) FORMATION AND EVOLUTION OF AEROSOLS IN FILTERED AIR AND IN NATURAL AIR. EFFECT OF RADIOACTIVITY. Madelaine, Guy J. (Commissariat a l'Energie Atomique, Fontenay-aux-Roses (France). Centre d'Etudes Nucleaires). 1968. 77p. (In French). Dep. Thesis. Submitted to Univ., Paris.

The formation, evolution, coagulation, and electrical charge of aerosols that form in natural filtered air containing only gaseous impurities, under the influence of solar light (photolysis) and radioactive disintegrations (radiolysis) are considered. The modifications brought about in the aerosol by an increase in the sulfur dioxide content and in the natural radioactive gas content are studied. The work was then repeated with nonfiltered air. A comparison was also made of the behavior of nonradioactive and radioactive particles. The possible consequences of these phenomena on the origin and the size distribution of particles occurring in the atmosphere are considered. (auth)

**17573** (FOA-4-4386) INVESTIGATIONS ON NUCLEAR DEBRIS FROM THE 7th CHINESE TEST. Sisefsky, J.; Persson, G. (Forsvarets Forskningsanstalt, Stockholm (Sweden)). Feb. 1969. 23p. Dep.

Debris from China's seventh nuclear test was examined with gamma spectrographic and autoradiographic methods. The "hot" particles are rather uniformly reddish, with a specific activity in the medium range. They displayed a normal fractionation, but the fractionation factors are independent of particle size in the range 0.4 to 4.5 μm. Debris, dissolved in precipitation water, displayed an "opposite" fractionation and it was shown that the "hot" particles and the soluble particulate are "mirror particulates", i.e., they represent the parts of a dual partition of the nuclear debris, originally formed. The partition-factors for the two particulates with respect to the most common gamma-emitting nuclides were calculated. The "hot" particles were found to have incorporated ca 90 percent of all atoms in mass-chain 95 formed. It was estimated that 2.4 ton of iron per kg of uranium were incorporated in the fire-ball. Particle spectra for different "hot" particle samples are given. The concept of mirror particulates is discussed theoretically and in the light of the particle formation model of B. Holmberg and S. Andersson. (auth)

**17574** (LA-4032) AEROSOL CONCENTRATION AND EXTINCTION IN THE EARTH'S ATMOSPHERE. Horak, Henry G. (Los Alamos Scientific Lab., N. Mex.). Oct. 1968. Contract W-7405-eng-36. 27p. Dep. CFSTI.

The scattering properties of the atmosphere are very largely determined by the aerosol content. A survey is presented of the subject with emphasis placed on aerosols above the troposphere. There are three major populations of aerosol particles: those smaller than 0.1-μ radius, which decrease in concentration from ~100/cm$^3$ at 10 km to nearly zero at 20 km; those of 0.1- to 2-μ radius with a maximum concentration of ~1.0/cm$^3$ at 20 km and a secondary maximum of ~0.003/cm$^3$ at 80 to 100 km (the altitude zone of noctilucent clouds); and those of greater than 2-μ radius which have an extremely low concentration in the stratosphere and above. The particles of the second population are the most effective in producing scattering and extinction in the visible wavelength region. Several methods for determining aerosol concentrations and extinction coefficients are described. Laser probing is most promising for future work. The results obtained by various investigators are presented, and clearly show that after the volcanic activity on Bali during the spring and summer of 1963 the aerosol extinction coefficient in the stratosphere increased by a factor of approximately ten. Large radioactive fallout particles (1 to 10 μ) exhibit atmospheric residence times of weeks to months, and radioactivity associated with particles of <0.02-μ radius above 27 km and with particles of ~0.1-μ radius in the lower strato-

sphere persists for years. Photometric observations made through the atmosphere are complicated by the effects of extinction and multiple scattering, especially for light paths close to the horizon. Calculations based on radiative transfer theory show that given reasonable atmospheric thicknesses and properties, and for a stellar source or for a uniformly emitting plane source on top of the atmosphere, the diffuse light can exceed the direct, exponentially reduced light for large zenith angles. This effect is enhanced by an increase in the number of aerosol particles and by the presence of a high albedo ground surface. Methods of correcting observations are discussed; extended sources are the most problematic, and the application of the Koschmieder–Barbier equation is described. (auth)

**17575** (NP-17772) THEORETICAL MODELS FOR THE BRIGHTNESS OF CONTAMINANT GLOW CLOUDS IN THE UPPER ATMOSPHERE. Technical Note HSA 84. Lloyd, K. H. (Weapons Research Establishment, Salisbury (Australia)). July 1963. 51p. Dep.

The theoretical variation in brightness which would be observed across a diffusion glow cloud released in the upper atmosphere is discussed. A Gaussian distribution for the contaminant number density is used, and it is assumed that when chemical reactions occur either the contaminant density is everywhere very small, or an insignificant quantity of contaminant is consumed. Both the cases of chemiluminescence and scattering of the sun's rays are examined, and the effects on the observed brightness of absorption, re-emission and scattering of radiation within the cloud are considered. The results may be used to interpret observations on upper atmosphere contaminant releases. (auth)

**17576** (UCRL-Trans-10327) HIGHLY RADIOACTIVE FALLOUT PARTICLES FROM THE CHINESE NUCLEAR TEST EXPLOSIONS. Maruyama, Hideo. Translated for Univ. of California, Lawrence Radiation Lab., Livermore, from Nagano Kogyo Koto Senmon Gakko Kiyo, 3: 167-73(1967). 13p. Dep. CFSTI.

An abstract of this paper, prepared from the original language, appeared as NSA 22: 27924.

**17577** VERTICAL DISTRIBUTION OF HEAVY RADIOACTIVE ADMIXTURES IN THE ATMOSPHERE. Jordanov, Dimitar. Izv. Geofiz. Inst., Bulg. Akad. Nauk, 11: 5-8(1967). (In Bulgarian).

The vertical distribution of heavy radioactive admixtures in the atmosphere is discussed. Equations are developed to calculate changes in the coefficients of exchange with altitude. It is proved that the concentration of heavy radioactive particles decreases more quickly with increases in altitude. (Abstr. of Bulg. Sci. Lit.)

**17578** DEPOSITION OF PLUTONIUM IN TOKYO THROUGH THE END OF 1966. Miyake, Yasuo; Katsuragi, Kukio (Meteorology Research Inst., Tokyo). Pap. Meteorol. Geophys. (Tokyo), 19: 267-76(July 1968).

Integrated amounts of $^{238}Pu$ and $^{239}Pu$ deposited in Tokyo during the period from March 1958 to the end of 1966 are 0.92 mCi/km$^2$ and 34 $\mu$Ci/km$^2$ respectively. $^{238}Pu$ to $^{239}Pu$ ratio from 1959 to 1966 is 3.9% which is nearly the same as that in fallout prior to the satellite failure. The mean ratio of $^{239}Pu/^{90}Sr$ deposition is 1.6%. Assuming 1.6% activity ratio of $^{239}Pu/^{90}Sr$, the total release of $^{239}Pu$ and $^{238}Pu$ associated with the nuclear test is estimated to be about 0.22 MCi and <10 kCi respectively in this period. The mean residence time of $^{239}Pu$ was 1.7 years in both periods from 1959 to 1961 and from 1963 to 1966, which is slightly longer than that of $^{90}Sr$ (1.4 yr., 1963 to 1966). (NSA of Japan)

**17579** ABOUT THE INFLUENCE OF THE KIND OF AIR MASS ON CONCENTRATION IN THE GROUND AIR LAYER OF NATURAL RADIONUCLIDES DERIVING FROM RADON AND THORON. Kopcewicz, Teodor (Univ., Warsaw). Przegl. Geofiz., 13: 333-44(1968). (In Polish).

Investigations on correlations between concentration of natural derivatives of radon and thoron in the air layer near the ground and the kind of air mass are discussed. Examples are given of the gradual increase in total $\beta$ activity in the air over Warsaw during the transformation process of polar masses. The time growth in mean diurnal activity of the air associated with the transformation process of maritime and Arctic polar masses is shown for all cases of the years 1965 and 1966 for the minimum and maximum periods of every active year and the complete computation results of mean diurnal air activity are listed with reference to air mass kind. The influence of certain meteorologic parameters on the intensity of ground emanation of radon and thoron and its connection with the annual cyclicity of air activity is discussed. Remarks on air mass transformation in nonsource regions are included with respect to their application to the interpretation of the obtained intensity records of air activity. (auth)

**17580** FRACTIONATION PHENOMENA IN ACTIVITY FROM AN UNDERGROUND NUCLEAR EXPLOSION. Persson, Gunnar (Research Inst. of National Defence, Stockholm). Health Phys., 16: 515-23(Apr. 1969).

Debris likely to have come from the underground nuclear explosion in the Semipalatinsk area on December 18, 1966, was found in ground-level air and precipitation samples, mainly in the northern part of Sweden, between December 22 and December 30. An examination of trajectories, verifying the fallout picture, was carried out. Gamma-spectrometric and radiochemical examinations showed that the debris was enriched in strontium-89, strontium-90, cesium-137 and barium(-lanthanum)-140 with respect to mixed fission products. All these nuclides have noble gases as precursors in their decay chains. Venting conditions are discussed, leading to the conclusion that a small release occurred after a time depending on the fission mode used, and in all cases within the first minute after the explosion. (auth)

**17581** RADIONUCLIDE FRACTIONATION IN FALLOUT PARTICLES FROM A LAND SURFACE BURST. Mamuro, T.; Matsunami, T.; Fujita, A.; Yoshikawa, K. (Radiation Center of Osaka Prefecture, Sakai, Japan). J. Geophys. Res., 74: 1374-87(Mar. 15, 1969).

The radionuclide fractionation appearing in individual hot particles (highly radioactive fallout particles) from the fifth Chinese nuclear explosion of December 28, 1966, which is believed to have been a land surface burst of several hundred kiloton yield, was investigated by $\gamma$-ray spectrometry. The activities of the ten radionuclides $^{95}Zr$, $^{97}Zr$, $^{99}Mo$, $^{103}Ru$, $^{131}I$, $^{132}Te$, $^{133}Xe$, $^{140}Ba$, $^{141}Ce$, and $^{239}Np$ were determined, and the initial atom numbers of these nuclides contained in each sample were estimated. The fractionation factors defined with respect to $^{95}Zr$ were calculated in order to express the degree of fractionation. The results obtained are discussed in relation to the fission-product decay chains and are compared with the results formerly obtained on hot particles from air bursts. It was found that there was considerable difference in radiochemical nature between these hot particles from a surface burst and the hot particles from air bursts. Some assumptions about the mechanism of fractionation in fallout particles are presented, although it now seems difficult to understand the mechanism satisfactorily. (auth)

**17582** $^{90}Sr$ YIELD OF THE 1967 CHINESE THERMONUCLEAR EXPLOSION. Volchok, H. L.; Kleinman, M. T. (Atomic Energy Commission, New York). J. Geophys. Res., 74: 1694-6 (Mar. 15, 1969).

Fallout from the reported thermonuclear detonation in June 1967 by the Communist Chinese was detected in New York City in early 1968. By using several empirical constants relating deposition in New York City to global meteorological phenomena, a $^{90}Sr$ yield for this test of 198 kCi was deduced. This result is in good agreement with the values obtained by other investigators. (auth)

**17583** RADIOACTIVE DUST FALLOUT IN BHAVNAGAR AREA. Suru, D. P.; Vaidya, V. H.; Rao, P. S. (Central Salt and Marine Chemicals Research Inst., Bhavnagar, India). Sci. Cult. (Calcutta), 34: 403-4(Sept. 1968).

Studies on the radioactive dust and rain fallout in the Saurashtra area are reported and compared with radioactive fallout data from other regions in India. Fallout was found to be heavier than in most other regions in India probably due to the northeasterly tides and the high wind velocities of the region. (F.S.)

**17584** ON THE LASTING RADIOACTIVITY OF ATMOSPHERIC AEROSOLS IN PLOVDIV. Ivanova, D.; Stefanova, M.; Gencov, D. (Higher Medical Inst., Plovdiv, Bulgaria). Folia Med. (Plovdiv), 9: 139-43(1967).

Beta-activity measurements were made on filtered aerosols in 1964 to 1966. The activity was measured in cpm, immediately after taking the samples, 2 hr and 15 min later, and after 72 hr. Conversion of the lasting $\beta$ activity from cpm to Ci/m$^3$ was made by comparison with the standards $^{90}Sr$ and $^{90}Y$. Changes of the average monthly values of the lasting $\beta$ activity of the air for the period 1964 to 1966 are shown. The average value obtained for the last 6 months in 1964 was $3.83 \times 10^{-12}$ Ci/m$^3$. The corresponding value for 1965 was $0.79 \times 10^{-12}$ Ci/m$^3$. The maximum average monthly value for 1964 was $6.64 \times 10^{-12}$ Ci/m$^3$, $1.42 \times 10^{-12}$ Ci/m$^3$ for 1965, and $1.76 \times 10^{-12}$ Ci/m$^3$ for 1966. Three maxima were seen, viz., for 1964 in July ($16.30 \times 10^{-12}$ Ci/m$^3$) and in November ($17.02 \times 10^{-12}$ Ci/m$^3$) and for 1966 in February ($12.96 \times 10^{-12}$ Ci/m$^3$). It was probable that they were due to atomic explosions. (BBB)

**17585** ARE PARTICULATE RADIOACTIVE TRACERS INDICATIVE OF STRATOSPHERIC MOTIONS. Telegadas, K.; List, Robert J. (Air Resources Labs., Silver Spring, Md.). J. Geophys. Res., 74: 1339-50(Mar. 15, 1969).

Measurements of radioactive particulate $^{90}Sr$ and gaseous excess $^{14}C$ (due to nuclear weapons testing) injected into the stratosphere in 1961 to 1962 were used to illustrate that particle settling appears to be insignificant on the time scale of a year or so. High $^{14}C$-to-$^{90}Sr$ ratios appear in balloon observations to 30 km at 31°N in 1963 and at later times at aircraft altitudes at 20 km and below over much of the northern hemisphere. The distribution is explained by the contribution of the two large nuclear tests in October 1961 that had low fission yields injecting large quantities of $^{14}C$ relative to $^{90}Sr$ to great heights in polar regions. High $^{14}C$-to-$^{90}Sr$ ratios also appear in the lower equatorial stratosphere (15 km) and appear to move poleward (at altitudes below 18 km), suggesting a possible meridional circulation. (auth)

**17586** ISSLEDOVANIE PROTSESSOV SAMOOCHISHCHENIYA ATMOSFERY OT RADIOAKTIVNYKH IZOTOPOV. Sbornik Dokladov, Prochitannykh na Soveshchanii v Palange, 7–9 Iyunya 1966 g. (Investigations of Atmospheric Self-Scavenging Processes from Radioactive Isotopes. Collected Reports on the Conference in Palanga, Lithuanian S.S.R., on July 7–9, 1966. Styro, B. I.; Garbalyauskasa, Ch. A.; Luyanasa, V. Yu. (eds.). Vilnyus, USSR, Izdatel'stvo Mintis, 1968. 352p. (CONF-660728).

The conference proceedings are divided into 6 sections and include 33 papers. The sections are entitled general meteorological aspects of self-refinement of the atmosphere from radioactive dust, fallout rate of radioactive materials from atmosphere to earth's surface, the course and characteristics of radioactive fallout, the questions of washout of radioactive isotopes in the atmosphere, radioactivity concentration in air layer near the ground by a self-scavenging process, and investigation of self-scavenging process of radioisotopes artificially injected into a cloud. Separate abstracts were prepared for 32 of the papers. (B.L.M.)

*For abstracts of individual papers see: 17587–17618.*

**17587** SELF-REFINEMENT OF THE ATMOSPHERE FROM RADIOACTIVE POLLUTION. Styro, B. I. pp 11-21 of Issledovanie Protsessov Samoochishcheniya Atmosfery ot Radioaktivnykh Izotopov. Styro, B. I. (ed.). Vilnyus, USSR, Izdatel'stvo Mintis, 1968. (In Russian).

From Conference on Investigations of Atmospheric Self-Scavenging Processes from Radioactive Isotopes, Palanga, Lithuanian SSR. See CONF-660728.

The processes of pollution of the atmosphere by radioactive admixtures are discussed. It is shown that self-purification processes take place alongside pollution. There is no information about penetration of radioactive substances into cosmic space though such a process is probable. Some fraction of the radioactive material disappears by radioactive decay but there are no complete quantitative evaluations of this process. The atmosphere is purified by deposition of radioactive substance on the earth's surface with dust. Precipitation and clouds washout the atmosphere, washout being the dominating factor in its purification. (auth)

**17588** METEOROLOGICAL EFFECTS ON TEMPORARY CHANGES IN LARGE-SCALE RADIOACTIVE ATMOSPHERIC POLLUTION OF NEAR-GROUND AIR LAYER. Koptsevich, T. pp 23-36 of Issledovanie Protsessov Samoochishcheniya Atmosfery ot Radioaktivnykh Izotopov. Styro, B. I. (ed.). Vilnyus, USSR, Izdatel'stvo Mintis, 1968. (In Russian).

From Conference on Investigations of Atmospheric Self-Scavenging Processes from Radioactive Isotopes, Palanga, Lithuanian SSR. See CONF-660728.

The influence of the polar jet stream on pollution change with time in Europe was studied on the basis of total pollution measurements of the lower atmospheric layers. An example for May of 1963 is given, and it shows the variation of air pollution with the meteorological situation at sea-level and on the isobaric 500 mb surface using, simultaneously, the data for temporary changes of the tropopause altitude. (auth)

**17589** DETERMINATION OF VERTICAL DISPLACEMENT OF AIR MASSES USING THE RADIOACTIVE ISOTOPES. Luyanas, V. Yu.; Shalaveyus, S. S. pp 37-41 of Issledovanie Protsessov Samoochishcheniya Atmosfery ot Radioaktivnykh Izotopov. Styro, B. I. (ed.). Vilnyus, USSR, Izdatel'stvo Mintis, 1968. (In Russian).

From Conference on Investigations of Atmospheric Self-Scavenging Processes from Radioactive Isotopes, Palanga, Lithuanian SSR. See CONF-660728.

Air vertical displacement was defined by correlation of the change of atmospheric concentration of $^{22}Na$ and $^{7}Be$. Several cases of sharp increases in these values were registered in 1965. In May the ratio $^{22}Na/^{7}Be$ several times reached the values characteristic of the stratospheric air. A special coincidence spectrometer was used for $^{22}Na$ concentration measurements in atmospheric air samples. The background was 1.5 counts/hr at a counting efficiency equal to 2.5%. $^{7}Be$ was measured according to the 478 keV $\gamma$ line. (auth)

**17590** PECULIARITIES OF SNOW COVER POLLUTION FROM DRY AND WET RADIOACTIVE FALLOUT IN MOUNTAINOUS PLACES. Manolov, L. S. pp 43-55 of Issledovanie Protsessov Samoochishcheniya Atmosfery ot Radioaktivnykh Izotopov. Styro, B. I. (ed.). Vilnyus, USSR, Izdatel'stvo Mintis, 1968. (In Russian).

From Conference on Investigations of Atmospheric Self-Scavenging Processes from Radioactive Isotopes, Palanga, Lithuanian SSR. See CONF-660728.

Samples taken from a snow cover at an altitude of 2200 m were analyzed. Additional factors (condensation and advection) influencing snow cover pollution are considered. The highest radioactivity was found on the surface of the snow cover in 1955. Activity of the analyzed layer depends on its exposure. The snow cover radioactivity does not descend from the surface, but it is accumulated in a layer 2 to 2.5 cm thick. Not every polluted layer is more radioactive, but every fallout-polluted layer is visually polluted. Surface pollution on the snow cover amounts to 1,570 Ci/km$^2$. (auth)

**17591** RADIONUCLIDE FRACTIONATION IN WEAPON DEBRIS LONG DISTANCES FROM BURSTS. Izrael, Yu. A. pp 57-63 of Issledovanie Protsessov Samoochishcheniya Atmosfery ot Radioaktivnykh Izotopov. Styro, B. I. (ed.). Vilnyus, USSR, Izdatel'stvo Mintis, 1968. (In Russian).

From Conference on Investigations of Atmospheric Self-Scavenging Processes from Radioactive Isotopes, Palanga, Lithuanian SSR. See CONF-660728.

On the basis of analysis of physical and chemical properties of air burst particles, a conclusion was drawn on the possibility of determining the dependence of fractionation factors on particle size by means of a scheme suggested in the early work by Ju. A. Israel for large particles of a surface burst. A technique for approximately estimating the fractionation factors in long-range fallout from underground nuclear explosion is given. (auth)

**17592** LATITUDINAL AND SEASONAL CHANGE OF RADIOACTIVE AEROSOL REMOVAL FROM THE LOWER TROPOSPHERE. Karol, I. L.; Krasnopevtsev, Yu. V.; Malakhov, S. G. pp 67-84 of Issledovanie Protsessov Samoochishcheniya Atmosfery ot Radioaktivnykh Izotopov. Styro, B. I. (ed.). Vilnyus, USSR, Izdatel'stvo Mintis, 1968. (In Russian).

From Conference on Investigations of Atmospheric Self-Scavenging Processes from Radioactive Isotopes, Palanga, Lithuanian SSR. See CONF-660728.

The monthly cleansing rate of the troposphere in 1963 to 1964 is defined by earlier published fallout data for nuclear explosions and their concentration in the air layer near the ground in a number of stations placed between 76° N and 52° S. This parameter is determined as a ratio of monthly isotope fallout to its monthly concentration and characterizes radioactive aerosols removal rate from the lower troposphere mainly by precipitation. The cleansing rate of $^{90}Sr$ has a marked latitudinal and seasonal change and correlates with the changes of monthly precipitation. The cleansing rate for a number of other isotopes, products of nuclear explosions, in comparison with the cleansing rate of $^{90}Sr$ was experimentally studied in the middle latitudes of northern hemisphere. (auth)

**17593** BALANCE AND REMOVAL RATE OF $^{90}Sr$ FROM THE ATMOSPHERE. Malakhov, S. G.; Pudovkina, I. B. pp 85-105 of Issledovanie Protsessov Samoochishcheniya Atmosfery ot Radioaktivnykh Izotopov. Styro, B. I. (ed.). Vilnyus, USSR, Izdatel'stvo Mintis, 1968. (In Russian).

From Conference on Investigations of Atmospheric Self-Scavenging Processes from Radioactive Isotopes, Palanga, Lithuanian SSR. See CONF-660728.

The $^{90}Sr$ fallout data obtained on the basis of measurements in different countries are compared. Calculated $^{90}Sr$ quarterly fallout in various latitudes in 1959 to 1964 is given. $^{90}Sr$ annual fallout from the atmosphere is compared with the amount of this isotope in the stratosphere. Then its removal rate from the atmosphere in both hemispheres is evaluated; $^{90}Sr$ transfer from northern to southern hemisphere is taken into account on the basis of relative rates for individual isotopes. Distribution of $^{90}Sr$ fallout by latitudes of both hemispheres in 1959 to 1964 and $^{90}Sr$ quarterly fallout distribution by latitudes were investigated. An attempt to evaluate the $^{90}Sr$ concentration in precipitation and its dependence on the amount of precipitation in the same latitude is made. (auth)

**17594** ON RaD DEPOSITION IN THE ATMOSPHERE. Styro, B. I.; Shalaveyus, S. S. pp 107-13 of Issledovanie Protsessov Samoochishcheniya Atmosfery ot Radioaktivnykh Izotopov. Styro, B. I. (ed.). Vilnyus, USSR, Izdatel'stvo Mintis, 1968. (In Russian).

From Conference on Investigations of Atmospheric Self-Scavenging Processes from Radioactive Isotopes, Palanga, Lithuanian SSR. See CONF-660728.

A method of $^{210}Pb$ measurement in the atmosphere and in dry and wet depositions is discussed. Lead was distinguished radiochemically by using ionic exchange resins. $^{210}Pb$ radioactivity was measured by means of an end-window counter. A curve of the annual course of $^{210}Pb$ concentration in dry and wet depositions, and in the air layer near the ground was obtained. It is shown that natural $^{210}Pb$ fallout density depends on precipitation intensity. Dilution effect and effective washout constant are defined. A $^{210}Pb$ deposition rate of $A \times 10^2$ m/day (where A is a coefficient that changes from sample to sample from units to tens) was calculated. It is shown that dry deposition of $^{210}Pb$ amounts to 24%. (auth)

**17595** ON VELOCITY OF SELF-SCAVENGING OF TROPOSPHERE FROM FISSION PRODUCTS AND ESTIMATION OF THE COEFFICIENT OF VERTICAL TURBULENT DIFFUSION IN HIGHER TROPOSPHERE. Makhon'ko, K. P. pp 115-23 of Issledovanie Protsessov Samoochishcheniya Atmosfery ot Radioaktivnykh Izotopov. Styro, B. I. (ed.). Vilnyus, USSR, Izdatel'stvo Mintis, 1968. (In Russian).

From Conference on Investigations of Atmospheric Self-Scavenging Processes from Radioactive Isotopes, Palanga, Lithuanian SSR. See CONF-660728.

A simple model for tropospheric self-scavenging from radioactive fission products coming from the stratosphere as a result of washout by precipitation and deposition owing to atmospheric turbulence is considered. The troposphere is divided into 3 horizontal layers situated one above another. In the first nearest the earth subcloud layer of the atmosphere (0 to 1 km) the removal of fission products occurs as a result of washout by falling rain drops and "dry" deposition. In the second layer (~1 to 5 km) the removal of radioactive dust takes place as a result of particle capture by cloud drops and "dry" deposition. In the third layer (~5 to 10 km) washout does not occur. Here only the effects of "dry" deposition are active. From the data on velocity of "dry" deposition and on coefficients of fission products washout in the first and second layers of the atmosphere the velocity of radioactivity removal in each layer and the time of self-scavenging are estimated. Calculations show that the total time of fission product removal from the troposphere is determined mainly by the time of their removal from the third layer ($t_3 \sim 20$ days); the time of removal from the first two layers is significantly less ($t_1 \sim 1$ day, $t_2 \sim 0{,}1$ day). The coefficient of turbulent diffusion in this layer ($k_z \sim 5$ m$^2$/sec) is estimated from the solution of the stationary equation of contaminant transport from the stratosphere into the troposphere. In May and June $k_z$ increases 1.5 times in comparison to its value in January and February. (auth)

**17596** THE LONG-LIVED $\alpha$ ACTIVITY DURING DECREASE PERIOD OF FISSION PRODUCT $\beta$ ACTIVITY IN THE ATMOSPHERE. Garbalyauskas, Ch. A. pp 125-33 of Issledovanie Protsessov Samoochishcheniya Atmosfery ot Radioaktivnykh Izotopov. Styro, B. I. (ed.). Vilnyus, USSR, Izdatel'stvo Mintis, 1968. (In Russian).

From Conference on Investigations of Atmospheric Self-Scavenging Processes from Radioactive Isotopes, Palanga, Lithuanian SSR. See CONF-660728.

Results of measurements of atmospheric fallout radioactivity in 1963 to 1965 show that ratio of $\beta$ activity in the fallout to the long-lived $\alpha$ activity varies from a maximum of 671 in 1963 to 1964 to a minimum of 25 by the end of 1965. Analysis of decreasing rate of both components of atmospheric fallout radioactivity gives the following values of effective half life: for $^{144}Ce$, 0.5; for $^{137}Cs$, 0.7; and for long-lived $\alpha$ activity, 1.8 years. Autoradiographic investigation of fallout samples prepared as thick radiation sources was carried out by measuring the length of those $\alpha$ tracks whose tangents of the angle of inclination to the photoemulsion surface were small. A certain analogy was found by comparing spectra of $\alpha$ track lengths obtained from thick-layered uranium standard and from atmospheric fallout samples. The assumed presence of $^{239}Pu$ is not clear probably because of interference of $\alpha$ track frequency peaks by their displacement to the short-length part of range. (auth)

**17597** SOME DATA OF CLEANSING RATE OF NUCLEAR DEBRIS FROM THE ATMOSPHERE IN THE DISTRICTS OF CONTINENTAL CLIMATE. Shem'i-zade, A. E. pp 135-8 of Issledovanie Protsessov Samoochishcheniya Atmosfery ot Radioaktivnykh Izotopov. Styro, B. I. (ed.). Vilnyus, USSR, Izdatel'stvo Mintis, 1968. (In Russian).

From Conference on Investigations of Atmospheric Self-Scavenging Processes from Radioactive Isotopes, Palanga, Lithuanian SSR. See CONF-660728.

The fallout density data and volume concentration of nuclear debris in the district of Tashkent are given. Evaluation of radioactive aerosol removal rate from the atmosphere was carried out with respect to correlation between density of fission products fallout per unit area and their volume concentration in the air layer near the ground. Comparison of monthly variation of above-mentioned removal rate with total monthly amount of precipitation leads to the assumption that the process of radioactive aerosol washout from a subcloud layer in the period of stratospheric fallout is not effective. (auth)

**17598** $^{210}Pb$ USE FOR STUDYING SELF-CLEANSING ATMOSPHERIC PROCESSES. Baranov, V. I.; Vilenskii, V. D. pp 141-9 of Issledovanie Protsessov Samoochishcheniya Atmosfery ot Radioaktivnykh Izotopov. Styro, B. I. (ed.). Vilnyus, USSR, Izdatel'stvo Mintis, 1968. (In Russian).

From Conference on Investigations of Atmospheric Self-Scavenging Processes from Radioactive Isotopes, Palanga, Lithuanian SSR. See CONF-660728.

Data obtained in the district of Moscow in 1961 to 1963 make it possible to determine the contribution of $^{210}Pb$ "dry" deposition as 52 ± 21% of the total fallout. The most intensive process of atmospheric self-cleansing takes place in spring and summer; spring self-cleansing processes being the most effective. The ratio of $^{90}Sr$ to $^{210}Pb$ gave a more precise definition of main regularities in seasonal changes of $^{90}Sr$ concentration in the tropospheric layers under cleansing. In particular it takes into account the influence of $^{90}Sr$ concentration maxima in fallout observed during the period of small atmospheric precipitation. (auth)

**17599** DIURNAL CONCENTRATION CHANGES OF LONG-LIVED RADON DECAY PRODUCTS IN NEAR-GROUND AIR LAYER. Vilenskii, V. D.; Karol, I. L.; Malakhov, S. G.; Makhon'ko, K. P.; Chernysheva, G. P. pp 151-5 of Issledovanie Protsessov Samoochishcheniya Atmosfery ot Radioaktivnykh Izotopov. Styro, B. I. (ed.). Vilnyus, USSR, Izdatel'stvo Mintis, 1968. (In Russian).

From Conference on Investigations of Atmospheric Self-Scavenging Processes from Radioactive Isotopes, Palanga, Lithuanian SSR. See CONF-660728.

Measurements of radon, $^{210}Pb$, and $^{210}Bi$ concentrations in the surface air layer were carried out near Moscow. Diurnal changes of the average time of natural radioactive aerosols present in the lower troposphere were evaluated by these measurements. The change of removal parameters of radioactive aerosols was compared with meteorologic data during measurements. (auth)

**17600** RADIOACTIVE FALLOUT IN THE DISTRICT OF VILNYUS IN 1962 TO 1965. Garbalyauskas, Ch. A.; Gedeonov, L. I.; Styro, B. I.; Sysoeva, L. N.; Yakovleva, G. V. pp 157-66 of Issledovanie Protsessov Samoochishcheniya Atmosfery ot Radioaktivnykh Izotopov. Styro, B. I. (ed.). Vilnyus, USSR, Izdatel'stvo Mintis, 1968. (In Russian).

From Conference on Investigations of Atmospheric Self-Scavenging Processes from Radioactive Isotopes, Palanga, Lithuanian SSR. See CONF-660728.

Measurements of $^{137}Cs$, $^{90}Sr$, $^{44}Ce$, $^{141}Ce$, and $^{95}Zr$ in radioactive fallout are discussed. The accumulation of these radionuclides in the earth's surface was determined. The absence of fractionation of these fission products by fallout was established by measurements of $^{95}Zr/^{144}Ce$, $^{141}Ce/^{144}Ce$, $^{144}Ce/^{137}Cs$ ratios. The dose rate from $\gamma$ radiation of these isotopes amounts to 10 MRAD/year. An attempt to find an empirical dependence of fallout on some meteorologic parameters was made. (auth)

**17601** ABOUT THE DRY FALLOUT OF RADIOACTIVE FISSION PRODUCTS ON THE EARTH'S SURFACE. Dmitrieva, G. V. pp 173-9 of Issledovanie Protsessov Samoochishcheniya Atmosfery ot Radioaktivnykh Izotopov. Styro, B. I. (ed.). Vilnyus, USSR, Izdatel'stvo Mintis, 1968. (In Russian).

From Conference on Investigations of Atmospheric Self-Scavenging Processes from Radioactive Isotopes, Palanga, Lithuanian SSR. See CONF-660728.

The deposition of fission products in dry days and in those with precipitation at one of the Belgium stations from June 1957 to December 1961 is considered. The part of dry fallout in some years varied from 10 to 47% of the total and averaged 27% (the number of dry and rainy days over the whole period was approximately the same). A clearly pronounced maximum of dry fallout was observed every year in March (the maximum wet fallout was registered more often somewhat later). The correlation coefficient between the average daily concentration of radioactive fission products in the surface air on dry days and the corresponding dry fallout over a whole period was 0.5, during the moratorium, 0.8 and during the period of tests, 0.1. The ratio of average annual fallout to average concentration of fission products in the air in dry days varied from 280 to 40 and averaged 100. (auth)

**17602** FORMS OF RADIONUCLIDES IN ATMOSPHERIC PRECIPITATION. Gedeonov, L. I.; Zhilkina, M. I.; Gritchenko,

Z. G.; Flegontov, V. M. pp 181-90 of Issledovanie Protsessov Samoochishcheniya Atmosfery ot Radioaktivnykh Izotopov. Styro, B. I. (ed.). Vilnyus, USSR, Izdatel'stvo Mintis, 1968. (In Russian).

From Conference on Investigations of Atmospheric Self-Scavenging Processes from Radioactive Isotopes, Palanga, Lithuanian SSR. See CONF-660728.

From 1961 to 1965 in the district of Leningrad a systematic study of fission products was carried out. $^{7}Be$, $^{54}Mn$, $^{90}Sr$, $^{137}Cs$ fell out mainly in the forms soluble in water and $^{91}Y$, ($^{95}Zr$ + $^{95}Nb$), $^{125}Sb$, $^{141}Ce$, $^{144}Ce$, chiefly in forms insoluble in water. $^{103}Ru$ and $^{106}Ru$ distribution has a more complicated character; 30% of it was found in the insoluble fraction and 70%, in the soluble one. Most of the total $\beta$ activity was associated with suspended particles of 0.1 $\mu$ size. With increasing age of the fission product mixture a tendency to a decrease of total $\beta$ activity associated with suspensions was noted. The kind of atmospheric precipitation (rain, snow) had no particular influence on individual radionuclide distribution between atmospheric precipitation fractions. Some parts of the radionuclides in samples of global atmospheric fallout are hardly soluble in HCl and $HNO_3$. (auth)

**17603** RELATION BETWEEN METEOROLOGICAL CONDITIONS AND ABSOLUTE MONTHLY MAXIMA OF OZONE IN NEAR-GROUND AIR LAYER AND ARTIFICIAL $\beta$ ACTIVITY OF THE AIR. Varmbt, V. pp 191-200 of Issledovanie Protsessov Samoochishcheniya Atmosfery ot Radioaktivnykh Izotopov. Styro, B. I. (ed.). Vilnyus, USSR, Izdatel'stvo Mintis, 1968. (In Russian).

From Conference on Investigations of Atmospheric Self-Scavenging Processes from Radioactive Isotopes, Palanga, Lithuanian SSR. See CONF-660728.

Ozone concentration and artificial radioactivity in the air layer near the ground at the station of Wahnsdorf from 1962 to 1964 are compared. During the moratorium period a certain correlation in the course of ozone and radioactivity was found. This indicates simultaneous ozone and radioactivity transfer from stratosphere into the near-ground air layer. Some increase of ozone and radioactivity was marked in southern currents at a level of 500 mbar and a decrease in their levels was found in northern streams. (auth)

**17604** DETERMINATION OF REMOVAL PARAMETERS OF NATURAL RADIONUCLIDES BY RADIOACTIVITY PROFILES OF DROPLETS IN CLOUDS. Styro, B. I.; Vebra, E. Yu.; Shopauskas, K. K. pp 203-10 of Issledovanie Protsessov Samoochishcheniya Atmosfery ot Radioaktivnykh Izotopov. Styro, B. I. (ed.). Vilnyus, USSR, Izdatel'stvo Mintis, 1968. (In Russian).

From Conference on Investigations of Atmospheric Self-Scavenging Processes from Radioactive Isotopes, Palanga, Lithuanian SSR. See CONF-660728.

A theoretical scheme of radioactivity distribution on droplets in a cloud and profiles of height vs radioactivity accumulated on droplets were calculated. Sampling methods and radioactivity measurements on cloud liquid are described. Experimental profiles were built. Comparison of observed and measured profiles showed the limitation of this theoretical scheme. Approximate evaluation of nonradioactive removal parameter of radioactive aerosols on droplets amounts to $\approx 10^{-4}$ sec$^{-1}$. (auth)

**17605** COEFFICIENT OF RADIOACTIVE AEROSOL ACCUMULATION BY ATMOSPHERIC PRECIPITATION. Gedeonov, L. I.; Gritchenko, Z. G.; Flegontov, V. M.; Zhilkina, M. I. pp 211-19 of Issledovanie Protsessov Samoochishcheniya Atmosfery ot Radioaktivnykh Izotopov. Styro, B. I. (ed.). Vilnyus, USSR, Izdatel'stvo Mintis, 1968. (In Russian).

From Conference on Investigations of Atmospheric Self-Scavenging Processes from Radioactive Isotopes, Palanga, Lithuanian SSR. See CONF-660728.

An attempt was made to find a quantitative dependence of specific water activity of atmospheric precipitation on activity of the air layer near the ground. It was found that for an individual observation point there is a direct proportionality between these two observed values. On the basis of numerous observation data in various countries the coefficient of proportionality (coefficient of radioactive aerosol concentration) was equal to $(1.0 \pm 0.3) \times 10^{6}$. Coefficients of concentration of radioactive aerosols of natural and artificial origin were almost equal in their values. The value of concentration coefficient was found empirically and can be used for radioactive fallout estimation by specific activity data of the air layer near the ground. (auth)

**17606** RADIOACTIVITY DISTRIBUTION OF PRECIPITATION PARTICLES. Styro, B. I.; Vebrene, B. K. pp 221-8 of Issledovanie Protsessov Samoochishcheniya Atmosfery ot Radioaktivnykh Izotopov. Styro, B. I. (ed.). Vilnyus, USSR, Izdatel'stvo Mintis, 1968. (In Russian).

From Conference on Investigations of Atmospheric Self-Scavenging Processes from Radioactive Isotopes, Palanga, Lithuanian SSR. See CONF-660728.

The radioactivity of 8000 individual rain drops and ice crystals was measured by means of nuclear emulsion. Frequency schemes of droplets and ice crystals of given specific radioactivity value are represented. Radioactivity frequence maxima for droplets ($2.5 \times 10^{3}$) and ice crystals ($40 \times 10^{3}$ $\alpha$ tracks/g) were marked on graphs. Activity accumulation on cloud elements was calculated by simplifying assumptions. Comparison of theoretical and experimental results showed that activation of droplets in a cloud mainly has a short period and radioactivity of these droplets does not reach equilibrium state. This indicates nonstationary processes in clouds. (auth)

**17607** PECULIARITIES OF VARIOUS DISPERSION AEROSOL WASHOUT FROM NEAR-GROUND AIR LAYER DUE TO NUCLEAR EXPLOSIONS. Gaziev, Ya. I.; Malakhov, S. G.; Nazarov, L. E. pp 229-41 of Issledovanie Protsessov Samoochishcheniya Atmosfery ot Radioaktivnykh Izotopov. Styro, B. I. (ed.). Vilnyus, USSR, Izdatel'stvo Mintis, 1968. (In Russian).

From Conference on Investigations of Atmospheric Self-Scavenging Processes from Radioactive Isotopes, Palanga, Lithuanian SSR. See CONF-660728.

Radioactive aerosols produced by nuclear explosions were divided in two size fractions using an impaction-filtration installation. These measurements were carried out in the district of Moscow in 1964 to 1966. Dependence of the relative part of the rough dispersion fraction of total $\beta$ activity of the aerosols on precipitation in various seasons of the year was investigated. The fraction of radioactive aerosols of more than 0.5 $\mu$ in diameter was washed out better than finer aerosols, and washout depended on the season of the year. (auth)

**17608** WASHOUT OF RADIOACTIVE ISOTOPES AND CHEMICAL COMPOUNDS FROM THE ATMOSPHERE. Makhon'ko, K. P.; Avramenko, A. S.; Makhon'ko, E. P. pp 243-56 of Issledovanie Protsessov Samoochishcheniya Atmosfery ot Radioaktivnykh Izotopov. Styro, B. I. (ed.). Vilnyus, USSR, Izdatel'stvo Mintis, 1968. (In Russian).

From Conference on Investigations of Atmospheric Self-Scavenging Processes from Radioactive Isotopes, Palanga, Lithuanian SSR. See CONF-660728.

Results of a survey of the literature on the concentration of individual radioactive isotopes and chemical compounds in the precipitation and in the air are given. Isotope washout is characterized by the ratio of their concentration in precipitation and air at an altitude of the cloud layer. The dependence of the concentration of various isotopes of global origin and chemical compounds in precipitation on the amount of precipitation was obtained. The differences in washout of various isotopes are given. Sulfates are shown to be washed out of the atmosphere a little less than other compounds. Approximately a diurnal period is required for washout of isotopes and sulfates from the atmosphere. Washout of contaminants, the main sources of which are industrial centers, is better near these centers and worse at a distance. An attempt is being made to explain the regularities by peculiarities of aerosol particle origin and their "aging" in the atmosphere. These factors affect the size of particles on which the intensity of their washout by precipitation depends. (auth)

**17609** QUESTION OF PRECIPITATION ACTIVATION. Shem'i-zade, A. E. pp 257-60 of Issledovanie Protsessov Samoochishcheniya Atmosfery ot Radioaktivnykh Izotopov. Styro, B. I. (ed.). Vilnyus, USSR, Izdatel'stvo Mintis, 1968. (In Russian).

From Conference on Investigations of Atmospheric Self-Scavenging Processes from Radioactive Isotopes, Palanga, Lithuanian SSR. See CONF-660728.

Qualitative experimental data representing processes of self-cleansing from radioactive aerosols in a continental climate area are described. Diurnal variation of natural radioactive aerosols in the air layer near the ground during rains and dependence of the monthly specific air activity on precipitation amount and number of rainy days during a month are analyzed. It was concluded that the role of precipitation in decrease of natural air radioactivity comes mainly from corking of soil capillaries that impedes diffusion of radiation. It is shown that concentration of nuclear debris of tropospheric fallout in near the ground air layer can decrease to a certain degree in very heavy rain. (auth)

**17610** $\beta$ ACTIVITY AND PRECIPITATION QUANTITY DEPENDENCE. Shimon, A. pp 261-7 of Issledovanie Protsessov Samoochishcheniya Atmosfery ot Radioaktivnykh Izotopov. Styro, B. I. (ed.). Vilnyus, USSR, Izdatel'stvo Mintis, 1968. (In Russian).

From Conference on Investigations of Atmospheric Self-Scav-

enging Processes from Radioactive Isotopes, Palanga, Lithuanian SSR. See CONF-660728.

Results of investigations of atmospheric precipitation and its long-lived $\beta$ activity are discussed. Yearly $\beta$ activity values were obtained in Hungary. Snow and rain are shown to have equally effective washout from the atmosphere. (auth)

**17611** RADIOACTIVE FALLOUT ON A SMALL AREA BY PASSING A SINGLE CLOUD SYSTEM. Shopauskas, K. K. pp 269-74 of Issledovanie Protsessov Samoochishcheniya Atmosfery ot Radioaktivnykh Izotopov. Styro, B. I. (ed.). Vilnyus, USSR, Izdatel'stvo Mintis, 1968. (In Russian).

From Conference on Investigations of Atmospheric Self-Scavenging Processes from Radioactive Isotopes, Palanga, Lithuanian SSR. See CONF-660728.

Precipitation sampling was carried out at 70 points in an experimental field equal to about 300 $km^2$. Precipitation gathered after each rain was evaporated and total background radioactivity measured. It is shown that when a single cloud system passes, the concentration as well as radioactivity density is very inhomogeneous over the territory. No correlation was found between fallout density, radioactivity concentration, and amount of precipitation. The influence of cloud processes on global radioactive fallout is marked. (auth)

**17612** GLOBAL $^{7}$Be-CONCENTRATION DISTRIBUTION IN NEAR-GROUND AIR LAYER. Lavrenchik, V. N. pp 277-81 of Issledovanie Protsessov Samoochishcheniya Atmosfery ot Radioaktivnykh Izotopov. Styro, B. I. (ed.). Vilnyus, USSR, Izdatel'stvo Mintis, 1968. (In Russian).

From Conference on Investigations of Atmospheric Self-Scavenging Processes from Radioactive Isotopes, Palanga, Lithuanian SSR. See CONF-660728.

Generalization of experimental data on concentration of $^{7}$Be in the air layer near the ground from 72°N to 70°S in the period 1959 to 1965 is presented. Comparison of observed meridional distribution with meteorologic elements confirms the hypothesis of the chief role of meridional atmospheric circulation in the process of $^{7}$Be transfer in the stratosphere on the earth's surface. (auth)

**17613** EXTRAORDINARY CASE OF THE RADIOACTIVITY INCREASE NEAR THE EARTH'S SURFACE. Tomashenko, R. pp 283-91 of Issledovanie Protsessov Samoochishcheniya Atmosfery ot Radioaktivnykh Izotopov. Styro, B. I. (ed.). Vilnyus, USSR, Izdatel'stvo Mintis, 1968. (In Russian).

From Conference on Investigations of Atmospheric Self-Scavenging Processes from Radioactive Isotopes, Palanga, Lithuanian SSR. See CONF-660728.

Synoptic conditions of a very high increase of radioactivity in the air layer near the ground in Central and Northern Europe in November 1962 were analyzed. Concentration increases of fission product radioactivity were observed on the western periphery of an anticyclone in Poland. In Warsaw, activity amounted to 150 $pCi/m^3$ and in mountainous stations only 3 to 4 $pCi/m^3$. The radioactive cloud moved northward according to surface winds. The altitude of the low polluted layers (of the order of 1000 m) was marked. It was concluded that the polluted air transfer to surface layers took place not on the territory under review but in the east. (auth)

**17614** ANALYSIS OF NEAR-GROUND AIR RADIOACTIVITY INCREASES IN THE WARM SECTOR OF CYCLONES. Kasatkina, V. I. pp 293-301 of Issledovanie Protsessov Samoochishcheniya Atmosfery ot Radioaktivnykh Izotopov. Styro, B. I. (ed.). Vilnyus, USSR, Izdatel'stvo Mintis, 1968. (In Russian).

From Conference on Investigations of Atmospheric Self-Scavenging Processes from Radioactive Isotopes, Palanga, Lithuanian SSR. See CONF-660728.

The increase of the radioactivity of the air layer near the ground in the warm sector of cyclones on the south side of the jet stream barocline was considered. It was concluded that this increase occurs due to sinking of the stratospheric air, which is involved in the troposphere in the region of the tropopause gap and while descending along the isentropic surfaces crosses the region of the jet stream and penetrates to the south side of the high frontal zone. (auth)

**17615** VARIATION OF FISSION PRODUCT CONCENTRATION IN NEAR-GROUND AIR LAYER IN DAYS WITH PRECIPITATION. Dmitrieva, G. V.; Makhon'ko, K. P. pp 303-11 of Issledovanie Protsessov Samoochishcheniya Atmosfery ot Radioaktivnykh Izotopov. Styro, B. I. (ed.). Vilnyus, USSR, Izdatel'stvo Mintis, 1968. (In Russian).

From Conference on Investigations of Atmospheric Self-Scavenging Processes from Radioactive Isotopes, Palanga, Lithuanian SSR. See CONF-660728.

Statistical data on the variation peculiarites of fission product concentrations in the air layer near the ground during periods of precipitation are considered. Investigations were conducted for the moratorium and the period of tests; for different regions; and for close points but situated at different heights. The first day of precipitation appeared to be not effective for scavenging the fission products. The following days with precipitation are characterized: during the moratorium by a decrease in concentration; and in the period of tests, by a considerable increase of near-the-ground air radioactivity when it rains, and by a decrease when it showers. Considerable difference was noted in the concentration variation for different amounts of precipitation during the moratorium and the period of tests. (auth)

**17616** ARTIFICIAL ATMOSPHERIC AEROSOL RADIOACTIVITY. Gedeonov, L. I.; Gritchenko, Z. G.; Zhilkina, M. I.; Flegontov, V. M. pp 313-20 of Issledovanie Protsessov Samoochishcheniya Atmosfery ot Radioaktivnykh Izotopov. Styro, B. I. (ed.). Vilnyus, USSR, Izdatel'stvo Mintis, 1968. (In Russian).

From Conference on Investigations of Atmospheric Self-Scavenging Processes from Radioactive Isotopes, Palanga, Lithuanian SSR. See CONF-660728.

Experimental data characterizing the specific radioactivity of atmospheric dust are described. The dust was gathered by atmospheric precipitation and air filtration in the district of Leningrad in 1959 to 1965. Investigation showed that the role of "secondary" components of radioactive fallout was small. Atmospheric dust pollution by long-lived fission products was very low and did not exceed 0.3 to 0.5% of yearly radioactive fallout. The main source of global radioactive fallout and atmospheric dust pollution by long-lived fission products was stratospheric pollution due to nuclear weapon tests. (auth)

**17617** WASHOUT OF ARTIFICIAL RADIOACTIVE ISOTOPES INJECTED INTO A CLOUD ACCORDING TO GROUND STATION DATA. Shopauskas, K. K.; Styro, B. I.; Vebra, E. Yu.; Vebrene, B. K.; Shalaveyus, S. S.; Shopauskene, D. A. pp 323-33 of Issledovanie Protsessov Samoochishcheniya Atmosfery ot Radioaktivnykh Izotopov. Styro, B. I. (ed.). Vilnyus, USSR, Izdatel'stvo Mintis, 1968. (In Russian).

From Conference on Investigations of Atmospheric Self-Scavenging Processes from Radioactive Isotopes, Palanga, Lithuanian SSR. See CONF-660728.

A method was developed for investigation of some of the characteristics of radioisotope washout from clouds. The radioisotopes $^{32}$P and $^{210}$Po were injected into a cloud by anti-hail rockets. Precipitation samples were gathered from an area of 300 $km^2$ into polyethylene vessels, and individual raindrop samples were gathered on filter paper. Washout rate was determined by isotope amount and concentration in the precipitation. The washout rate was shown to be essentially dependent on time and position of isotope injection into the cloud. Different types of washout in various cloud zones are indicated. (auth)

**17618** WASHOUT CHARACTERISTICS OF $^{32}$P AEROSOLS INJECTED INTO CLOUDS. Burtsev, I. I.; Malakhov, S. G.; Burtseva, L. V. pp 335-45 of Issledovanie Protsessov Samoochishcheniya Atmosfery ot Radioaktivnykh Izotopov. Styro, B. I. (ed.). Vilnyus, USSR, Izdatel'stvo Mintis, 1968. (In Russian).

From Conference on Investigations of Atmospheric Self-Scavenging Processes from Radioactive Isotopes, Palanga, Lithuanian SSR. See CONF-660728.

A study using the radioactive tracer $^{32}$P for studying washout rate of aerosols and for evaluation of reagent propagation is described. Artificial action on hail clouds was carried out by an artillery missile. It is found that the distribution of the reagent's essential quantities varied inversely with radioecho transfer from cloud elements. Average coefficient of washout of $^{32}$P aerosol injected into the central part of a cloud is equal to $6 \times 10^{-4}$ $sec^{-1}$, into lower part, $2 \times 10^{-4}$ $sec^{-1}$. (auth)

## Mineralogy and Exploration

*Refer also to abstract 17570.*

**17619** (CU-1936-21) ORIGIN OF PLATEAU URANIUM ORES: WITH EMPHASIS ON MINERALIZATION AND ALTERATION. Progress Report for 1968. (Columbia Univ., New York. Dept. of Geology). Nov. 1968. Contract AT(30-1)-1936. 11p. Dep. CFSTI.

Evidence seems to show that in the Grants area, the U was deposited in the plateau during the Jurassic. Both detrital plant remains and petroleum were involved in U precipitation with a preponderance for deposition in accumulations of plant detritus. Copper deposition occurred at a separate time with Cu ores containing little if any U and U deposits containing only a small amount of Cu. It is postulated that the Orphan pipe resulted from solution collapse. The Orphan load is an epegenetic hydro-

thermal deposit only remotely affiliated with igneous activity. The sulfur came from $H_2S$ in the sediment according to isotopic data. The $H_2S$ caused bleaching and provided a reducing environment for ore precipitation. Pu/U dating was completed on the ore deposits of the Todilto Formation and mineralogical studies are in process. (F.S.)

**17620** CURIENITE, A NEW MINERAL SPECIES. A STUDY OF THE SERIES FRANCEVILLITE-CURIENITE. Cesbron, Fabien (Laboratoire de Mineralogie-Cristallographie, Paris); Morin, Noel. Bull. Soc. Fr. Miner. Crist., 91: 453-9(Sept.-Oct. 1968). (In French).

Curienite $Pb(UO_2)_3(VO_4)_2 \cdot 5H_2O$ was found in mineralized sandstones of the uranium-vanadium mine of Mounana, Gabon. Crystals are orthorhombic, space group Pcan, a = 10.40, b = 8.45, c = 16.34 Å and Z = 4. The strongest lines of the x-ray powder diagram are 8.19 (vs), 5.13 (s), 4.22 (s), 4.10 (vs), 3.226 (ms), 3.005 (vvs), 2.116 (ms). Curienite occurs as a yellow microcrystalline powder on francevillite crystals. S. G. 4.88, the refractive indices are higher than 2.2 V = −66°. Analysis gave $UO_3$ 53.40, $V_2O_5$ 17.32, PbO 20.09, BaO 0.84, $H_2O$ 8.30, sum 99.95%. Synthesis is readily obtained by mixing solutions containing $V_2O_5$, uranyl nitrate and lead nitrate and then heating the product in a sealed tube at 180°C. DTA curves show endothermic breaks at 190, 710 and 910°C. Comparisons are established with francevillite from the same mine, the properties of which were redetermined. The name is for Professor Hubert Curien; type material is preserved at the Laboratoire de Minéralogie-Cristallographie, Faculté des Sciences, Paris. (tr-auth)

**17621** APPLICATION OF LEAD ISOTOPIC COMPOSITION VARIATIONS FOR URANIUM DISTRICT STUDIES. Tugarinov, A. I.; Ordynets, G. E.; Shcherbakova, R. N.; Krys'kov, E. I. At. Energ. (USSR), 25: 483-9(1968). (In Russian).

The geochemical conditions of the radiogenic lead distribution around uranium deposits are discussed. An example of the lead isotopic composition variations in the uranium district rocks is given. These variations may be used as one of the criteria of uranium prospecting. The main criterion is the presence of the anomalous lead in the feldspars. (auth)

**17622** RADIOELEMENTS IN ROCKS OF THE TOKOV GRANITE MASSIF. Ushakova, A. M. (Inst. of Geological Sciences, Kiev). Geokhimiya, No. 2, 228-31(Feb. 1969). (In Russian).

The distribution of U and Th minerals in the Tokov granite massif, at the lower portion of the Kamenka river was determined. The mean concentration of U and Th in the granite was found to be $15.1 \times 10^{-4}$% and $14.6 \times 10^{-3}$%, respectively, yielding a Th/U ratio of about 10. The Th content was found to be fairly uniform throughout the system but the U content varied from $11.1 \times 10^{-4}$ to $12.8 \times 10^{-3}$%; this was attributed to the deposition of uranium-bearing minerals in the minute cracks of the rocks. The quartz-feldspar pegmatites were depleted in radioelements but exhibited the Th preponderance of the granites, with a Th/U ratio of about 8. The biotite-type pegmatites were more enriched in radioelements, especially in U, so that the Th/U ratio decreased to about 2. The haplites contained more Th but the overall concentration of the radioelements decreased. The largest U and Th concentrations were encountered in the metasomatic magnetite–biotite formations, in which the U was even more enriched, with Th/U ratios ranging from 1.3 to 3.2. The accumulation of U is attributed to postmagmatic and other secondary processes. (TTT)

**17623** STATE OF AFFAIRS OF CZECHOSLOVAK URANIUM. Lehky, Ludek. Veda Tech. Mladezi, No. 12, 402-5(1968). (In Czech).

Questions are answered in an interview relating to Czechoslovak U. The capacity of the mines, methods of mining, and the price of uranium were discussed. The cost of uranium mining cannot be disclosed. No Soviet miners are now in the Czechoslovak mines, but there are Soviet consultants and experts. Convicts employed in the mines work under conditions equal to those of the other workers. High safety standards are observed. (JPRS)

**17624** URANIUM FOR THE EUROPEAN COMMUNITY. Spaak, F. Energ. Nucl. (Milan), 16: No. 3, 32-43(Mar. 1969).

The situation of the natural uranium industry in the European Community, the efforts and results of the prospection activities in the different member countries and estimates on the reasonably assured and possible additional uranium reserves workable at a price of $8.00 to 10.00 lb/$U_3O_8$ are outlined. The present production programs based on reserves, the size and scope of current prospection activities estimated and compared with similar activities elsewhere in view of the predicted medium and long term requirements of the nuclear industry, and the role and activities of the European Community in the field of nuclear supply as well as ways and means provided by the Euratom Treaty to develop a viable European natural uranium industry are reported. (auth)

## Oceanography

**17625** (AD-674858) WAVE RUNUP, MONO LAKE TESTS, 1965: A SUMMARY OF THEORETICAL PREDICTION METHODS AND SOME COMPARISONS WITH EXPERIMENTAL DATA. Final Report. Bertram, J. R.; Kriebel, A. R. (URS Corp., Burlingame, Calif.). June 1968. Contract Nonr-4959(00). 22p. (URS-654-5). CFSTI.

A literature survey on water-wave runup on sloping beaches is presented with a comparison of theory and measurements from the 1965 Mono Lake test series. These measurements of runup were about twice as large as predicted because the incident wave height was also about twice as large as predicted. A simplified calculative technique is presented which predicts the measured runup within 10 percent from the wave data measured in deep water. (auth) (USGRDR)

**17626** (AEC-tr-7030, pp 75-105) STRATOSPHERIC FALLOUT IN THE OCEANS OF THE NORTH TEMPERATE ZONE. Karol', I. L. Translation of report A-AC-82/G/L-1249.

Comparisons of the measured content of isotopes in soils and in vertical columns of seawater at the same latitudes and time showed that the $^{137}Cs$ and $^{90}Sr$ in the water columns were 3 to 6 times higher than the similar contents in soils. Therefore, a study was made of factors which affect the removal of radioactive aerosols, i.e., products of nuclear explosions, from the troposphere and their deposition onto the surface of the continents and oceans. A mathematical model developed for examining, qualitatively and quantitatively, the influence of physico-climatic mechanisms on the transport of stratospheric fallout by precipitation and dry deposition, is described. Results of calculations using this model indicate that global fallout onto continents and oceans in the same zone should be equal, and that more information on fallout mixing in the deep ocean layers must be obtained in order to explain the high fallout content measurements made in the near-surface layer ocean water. (L.C.L.)

**17627** (UCRL-50538) NUMERICAL CALCULATIONS OF VISCOUS INCOMPRESSIBLE STRATIFIED SHEAR FLOWS. Crowley, W. Patrick (California Univ., Livermore. Lawrence Radiation Lab.). Nov. 1, 1968. 44p. Dep. CFSTI.

The overturning of a finite perturbation in a gravitational field is considered as an initial-boundary-value problem in hydrodynamics. The equations of motion are nonlinear, and a numerical algorithm for solving them is proposed and analyzed. Numerical solutions are obtained for Richardson numbers in the range of 0.1 to 10. (auth)

**17628** STUDY OF THE $^{234}U/^{238}U$ RATIO IN CORE SAMPLES OF SEDIMENTS NEAR SEASHORES: VARIOUS EFFECTS. Bernat, Michel; Allegre, Claude (Faculte des Sciences, Paris). Compt. Rend., Ser. D, 268: 641-4(Jan. 27, 1969). (In French).

The variations in the $^{234}U/^{238}U$ observed in the core samples that were studied appear to be due to a variation in the detrital/authigenic ratio for uranium in the sediments. Consideration was given to the possibility that this interpretation is equally valid for the pelagic sediments studied by Teh Lung Ku. If this is true, it is necessary to abandon the idea of transfer into the seawater of $^{234}U$ by the sediments. This would have important consequences on the geochemical balance of uranium. (cf. Veeh, Earth Planet. Sci. Lett., 3: 145–50(Nov. 1967); NSA 22: 8233). (tr-auth)

**17629** RATE OF RECENT SEDIMENTATION IN THE OCEAN. Kuznetsov, Yu. V. Geokhimiya, No. 3, 251-60 (Mar. 1969). (In Russian).

A determination of the rate of recent sedimentation in the Indian and Pacific Oceans was carried out using data on the $^{230}Th$, $^{231}Pa$, and $^{238}U$ concentrations in oceanic waters and surface layers of oceanic sediments. The obtained results on the rate of recent sedimentation agree well with available publications on this question. The revealed variations in the rate of sedimentation in various regions of oceans are conditioned by the peculiarities of the hydrological regime in these regions. (auth)

**17630** DISCUSSION OF PAPER BY Y. HORIBE AND N. OGURA, "DEUTERIUM CONTENT AS A PARAMETER OF WATER MASS IN THE OCEAN". Sugiura, Yoshio (Meteorological Research Inst., Tokyo). J. Geophys. Res., 74: 1705-8 (Mar. 15, 1969).

The distribution of deuterium in the Kuroshio Current and the deuterium content of deep water in the Kuroshio region are discussed. It was found that the distribution of deuterium resembles the salinity distribution as far as waters above the salinity-

minimum layer are concerned. It was also shown that the deep water in the Pacific basin has the lowest deuterium content whereas deep water in the Philippine basin has a higher value. It is not true that only deuterium is characteristic in identifying the peculiarity of the ocean waters. (F.S.)

**17631** THORIUM ISOTOPES IN THE MARINE ENVIRONMENT. Bernat, Michel; Goldberg, Edward D. (Univ. of California, San Diego, La Jolla). Earth Planet. Sci. Lett., 5: 308-12(Jan. 1969).

Analyses of thorium isotopes isolated from fractions of a North Pacific Core, representing authigenic and detrital minerals, indicated that there were movements of $^{228}Ra$ within the sedimentary column, that the thorium comes to the deposit primarily from seawater, that there is no evidence for the migration of thorium isotopes within the sedimentary column, and that there is a continued growth of phillipsite at depths in the column. Finally, there appeared to be a preferential accommodation of $^{231}Pa$ and/or $^{227}Ac$ in the phillipsite, the authigenic zeolite, relative to the detrital minerals. The high values of the $^{228}Th/^{232}Th$ ratios in seawater may be influenced by the contribution of $^{228}Th$ arising from $^{228}Ra$ migration through the water-sediment interface. (auth)

**17632** ON THE STRONTIUM CONTENT OF THE SOUTHERN BALTIC WATERS. Bojanowski, Ryszard; Ostrowski, Stanislaw (Marine Station , Sopot, Poland). Acta Geophys. Pol., 16: 351-6(1968).

The strontium content of southern Baltic seawater was studied. The effect of isolation from the system of the world's ocean and the effect of this isolation on the formation of the ionic ratios of Sr/Cl and Sr/Ca in its waters were determined. Results of the Sr/Cl ratios showed the ratio for Baltic seawater is slightly less than water from other seas and the ratio of the strontium content to salinity remains constant. An increase in Sr content with depth runs parallel to salinity variations. The enrichment of Baltic Sea waters in chlorine was discussed. (F.S.)

## Seismology

*Refer also to abstracts 17638 and 17642.*

**17633** ELASTIC FREE-FIELD MOTION DUE TO NUCLEAR AIR BLAST. Fugelso, Leif E. (General American Research Div., Niles, Ill.); Waddick, Robert K.; Neidhardt, Glen L. J. Eng. Mech. Div., Proc. Amer. Soc. Civil Eng., 94: 1337-64(Dec. 1968).

The results of a series of numerical computations of free-field ground motions in a linear-elastic, homogeneous, isotropic half-space, in the plane-strain approximation induced by the air-blast load from a surface nuclear burst, provided numerical predictions of the ground motion. Such free-field information is useful in the design of near-surface structures which are subjected to high air-blast overpressures from a surface nuclear burst. Certain aspects of protective design require the knowledge of the maximum motions that might be obtained in the free field. The parametric dependence of the peak velocities and peak stresses that might be expected in an elastic half-space due to the air blast from a surface nuclear burst are presented. A wide range of P-wave velocities was considered, such that both transseismic and superseismic loading configurations were well documented. Variations of Poisson's ratio included those representative of most natural materials. Detailed histories of stress, velocity, and displacement for typical transseismic and superseismic motions were included for more complete characterization of the free-field environment. (BBB)

# ENGINEERING

## Nuclear Explosions

*Refer also to abstracts 17318, 17553, 17573, 17625, and 17824.*

**17634** (AD-673997) SELECTED METHODS FOR ANALYZING THE STABILITY OF CRATER SLOPES. Final Report. Banks, D. C. (Army Engineer Waterways Experiment Station, Vicksburg, Miss.). July 1968. 67p. CFSTI.

The results of a study to select methods for analyzing the stability of crater slopes are presented. Information is given on the nature of input required, such as crater geometry, unit weights, shear strength, and seepage pressures. The selected methods are discussed in detail, and examples of their application are presented. All methods which are found in literature are not described. The three methods presented are: the Bishop method of slices for circular slip surfaces; the extension of Bishop's method to composite failure surfaces as proposed by Janbu and Nonveiller; and the Seed and Sultan method of wedges. These methods were selected as representative of the best available limiting equilibrium procedures. (auth) (USGRDR)

**17635** (HN-20-1020) SALT CAVITY ENGINEERING AT TATUM. Jackson, Melvin W. (Argonne National Lab., Idaho Falls, Idaho); Pack, Phillip D. (Holmes and Narver, Inc., Las Vegas, Nev. On-Continent Test Div.). Feb. 1969. Contract AT(29-2)-20. 22p. (CONF-690206-1). Dep. CFSTI.

From Annual Meeting of the American Institute of Mining, Metallurgical, and Petroleum Engineers, Washington, D. C.

A large cavity could be of value in the study of the detection or concealment of underground nuclear explosions. Studies are reviewed relating to the excavation of large cavities in salt by mining and by solution. The utilization of the Tatum salt dome for the proposed site of a large excavated cavity is discussed. Sufficient information has been developed to indicate the probability that the proposed cavity construction is feasible, although there still exist problems involving stability, mechanics of the material, development of economic techniques, and construction management. (J.C.W.)

**17636** (NCG-TR-2) NUCLEAR CONSTRUCTION ENGINEERING TECHNOLOGY. Final Report. Hughes, Bernard C. (Army Engineer Nuclear Cratering Group, Livermore, Calif.). Sept. 1968. 182p. Dep. CFSTI.

A discussion of the basic concept of using nuclear explosives for construction purposes and a description of the types of projects which appear to have the greatest potential as nuclear construction applications is presented. An explanation of the elements which must be considered in assessing the engineering feasibility of using nuclear construction methods is included together with a recommended procedure which may be used in accomplishing the design. Data are presented pertaining to the phenomenology of nuclear crater formation as well as information concerning the techniques currently available for predicting the engineering characteristics of nuclear craters and evaluating, in turn, the potential long-term engineering behavior of nuclear excavations. Technical data pertaining to the safety considerations of the radioactivity release, seismic propagation and airblast which accompany a subsurface nuclear detonation and methods for assessing the impact that these phenomena will have on project feasibility are also presented. Engineering criteria which may be used in the design of specific nuclear construction projects and information concerning the conventional construction requirements which must be accomplished in conjunction with nuclear excavations are presented. The scope of nuclear field operations which must be accomplished in order to emplace and detonate nuclear explosives in a manner that will insure public safety is discussed. A discussion of the items which must be considered in estimating the overall cost of a nuclear construction project and quantitative cost estimating data for use in evaluating the economic feasibility of a given project is presented. A typical detailed nuclear construction feasibility study is presented. The manner in which the technical data provided in this report may be used is illustrated. Guidelines for accomplishing the design of a nuclear construction project are also offered. (auth)

**17637** (PNE-1107(Pt.2)) CRATER STUDIES: SURFACE MOTION. Project PRE-GONDOLA I. Final Report. Christopher, W. G.; Lattery, J. E. (Army Engineer Nuclear Cratering Group, Livermore, Calif.). Nov. 1968. 45p. Dep. CFSTI.

Project Pre-Gondola I was a series of four 20-ton chemical explosive, single-charge cratering experiments in weak, wet clay shale. Motions of the ground surface were measured by high-speed photography of surface targets which had been positioned as far as 96 feet from each surface ground zero (SGZ). The results indicated that the maximum SGZ velocities recorded for these detonations were larger than those for cratering detonations in other media at comparable scaled burial depths. The four Pre-Gondola I detonations produced maximum SGZ velocities of 255, 200, 167, and 139 ft/sec for scaled burial depths of 152, 167, 187, and 202 ft/kt$^{1/3}$, respectively. Maximum resultant surface velocities for the three shallowest detonations varied approximately as the $-2.2$ power of the radial distance from the charge. The maximum resultant surface velocities for the deepest detonation varied approximately as the $-2.9$ power of the radial distance from the charge. (auth)

**17638** (SC-DC-69-1641) INTRUSION MONITORING FOR THE UNATTENDED SEISMOLOGICAL OBSERVATORY. [Stokes, P. A.] (Sandia Labs., Albuquerque, N. Mex.). [nd]. 12p. (CONF-690202-1). Dep. CFSTI.

From Convention on Aerospace and Electronic Systems, Los Angeles, Calif.

An observatory was designed for the detection and recording of seismic disturbances related to underground nuclear bursts. Characteristics and a description of all systems are summarized. The protective requirements and philosophy and the protective system criteria are given. An effective Intrusion Detection System can be included as part of Unattended Seismological Observatory (USO) to aid in verifying compliance with a treaty on underground nuclear testing. (J.C.W.)

**17639** (SC-RR-68-655) AIRBLAST AND CRATERS FROM ROWS OF TWO TO TWENTY-FIVE BURIED HE CHARGES. Vortman, L. J. (Sandia Labs., Albuquerque, N. Mex.). Jan. 1969. 218p. Dep. CFSTI.

Airblast was measured perpendicular to and off the ends of row-charge explosions and compared with airblast from single charges. It was found that $p_{row} \approx n^{\beta} p_{single}$, where p is peak overpressure and n the number of charges. $\beta$ was different for each blast parameter examined: ground-shock-induced peak overpressure, peak overpressure from venting gas, peak negative pressure, and positive and negative impulse. Values of $\beta$ increased as spacing decreased. Airblast was always greater perpendicular to the row than off the end, by an amount which increased as the number of charges increased. (auth)

**17640** (UCRL-50465) STERLING REENTRY. Guido, Raymond S. (California Univ., Livermore. Lawrence Radiation Lab.). Dec. 15, 1968. 31p. Dep. CFSTI.

The Sterling Event was a 380-ton nuclear detonation conducted in the cavity remaining from the Salmon Event at a depth of 2717 ft in the Tatum salt dome near Hattiesburg, Miss. The reentry operation was undertaken to determine the general cavity conditions i.e., shape, temperature, pressure and radiation levels. The cavity investigation was conducted by reentry through the Sterling emplacement casing into the standing cavity. The original emplacement hole as represented by the conditions in the casing still has good integrity. The cavity was found to have a slight positive pressure (under 2 psig) upon reentry. Temperatures and radiation levels were obtained by in-hole geophysical logging tools. The levels measured were as predicted for temperatures ranging in the mid-150°F. The radiation levels in the cavity ranged from 25 to 45 mR/hr increasing as the detector approached the cavity bottom from 2660 to 2742 ft. A local high radiation level was found between the open cavity and the bottom of the diagnostic canister, i.e., the conical collapse zone from 2640 ft to 2660 ft in the hole. This level peaked at about 250 mR/hr. The general shape of the post Sterling cavity is the same as the pre-Sterling configuration except for a rubble pile in the center of the floor covering perhaps some 50 ft in diameter and approximately 11 ft high in the center of the floor tapering to the original floor level at the outside of the 50-ft diameter. A volume approximation was obtained by pressurization and flow test in the cavity. This indicated a volume of 630,000 ± 50,000 cu ft. This volume falls within the variation of a similar measurement made on the pre-Sterling cavity. Gas samples in the cavity were obtained and analyzed. These analyses showed the cavity gas is similar to normal air with no hazardous environmental conditions. The cavity floor was cored to a depth of 2762 ft. No recovery was obtained through the 11 ft of rubble. Approximately 8 ft of core was recovered from the area below the rubble. In this core the Sterling melt is represented in the first foot with the remaining showing some slight mixing of Sterling debris/Salmon melt and unaffected Salmon melt. (auth)

**17641** (UCRL-50562) A NEW APPARATUS FOR PERMEABILITY MEASUREMENTS UNDER LITHOSTATIC CONDITIONS AND RESULTS ON DROP FRACTURED AND HIGH EXPLOSIVE FRACTURED OIL SHALE. Lakner, John F. (California Univ., Livermore. Lawrence Radiation Lab.). Sept. 10, 1968. 14p. Dep. CFSTI.

An apparatus was designed and constructed to measure permeability of porous media under confining pressures up to 1000 atm and temperatures to 100°C, allowing simulation of lithostatic conditions encountered at depths where nuclear detonations occur. Gas flow through the specimen is controlled at pressures to 100 atm. Specimens are encapsulated in a resin and pressurized by silicone oil. The apparatus is also suitable for runs at 1 atm provided the specimen is cast in rigid plastic. Permeability measurements were made on consolidated oil shale and shale cracked by a dropped weight and by a high explosive detonator. Permeability is calculated from Forchheimer's equation, which reduces to Darcy's equation when inertial effects are small. The permeability of the consolidated unfractured shale is essentially zero. Oil shale samples cracked in a direction parallel to the bedding plane by the dropped weight method show the highest permeabilities, 0.6 to 0.8 millidarcies (md), at 0.3 kbar confining pressure. Samples cracked in the perpendicular direction by the drop method have lower permeability, $1 \times 10^{-3}$ md. Samples cracked by the high explosive detonator in a direction parallel and also perpendicular to the bedding plane produced the lowest permeabilities, $3 \times 10^{-5}$ and $1 \times 10^{-4}$ md, respectively. Permeability values are dependent on confining pressure as expected. For the parallel drop test permeability is roughly inversely proportional to confining pressure. (auth)

**17642** (UCRL-50563) SCALED FREE-FIELD PARTICLE MOTIONS FROM UNDERGROUND NUCLEAR EXPLOSIONS. Wheeler, V. E.; Preston, R. G. (California Univ., Livermore. Lawrence Radiation Lab.). Aug. 1, 1968. 29p. Dep. CFSTI.

A survey was made of results of experiments on motions of particles in stress waves generated by underground explosions. Magnitudes of free-field particle motions depend upon yield and the physical properties of the explosion medium or environment. Equations relating scaled free-field acceleration, peak radial stress, velocity, and displacement were derived from statistical fits to observations and are valid over limited scaled ranges but are adequate for use in problems of potential damage to nuclear test facilities. (F.S.)

## Facilities and Equipment

*Refer also to abstracts 17676, 17729, 17735, 17736, 18200, 18475, 18538, 18549, 18556, 18588, and 19613.*

**17643** (BAW-1280-57) SODIUM-HEATED STEAM GENERATOR DEVELOPMENT. Quarterly Progress Report, April-June 1968. (Babcock and Wilcox Co., Barberton, Ohio. Power Generation Div.). Dec. 28, 1968. Contracts AT(11-1)-1280; 610-0170. 14p. Dep. CFSTI.

Work Performed under United States-Euratom Fast Reactor Exchange Program.

A comparison was made of operating characteristics of prototype steam generators designed for 254, 400, and 500 psi water side pressure drop for evaluating the modifications that will be required for redesign and fabrication of the prototype steam generator. Work was held up on Task II the Sodium to Steam Heat Exchanger Study. Work continues under Task III to recommend a reactor vessel concept for FFTF. An annular design and a bottom inlet design are being compared. (auth)

**17644** (BNL-13285) DESIGN OF REFORMER FOR FOSSIL-NUCLEAR FUELED MHD POWER CYCLE. Katz, H.; Steinberg, M. (Brookhaven National Lab., Upton, N. Y.). Sept. 1968. 28p. Dep. CFSTI.

Two designs for a reformer for a fossil-nuclear fueled MHD power cycle are presented. Parameters considered in the designs were reaction kinetics; heat transfer through column walls and internal tubes; and the effects of compression, excess steam, and steam dilution requirements, and methane production on the cycle efficiency. More data are required on reaction kinetics, product distribution, fluidization properties, and the corrosion resistance and strength of construction materials. (F.S.)

**17645** (EUR-3940-3) RESEARCH AT ISPRA, 1961-1967. PART III. ENGINEERING. (European Atomic Energy Community, Ispra (Italy). Joint Nuclear Research Center). 1968. 304p. UK $6.00.

Engineering research work undertaken at the Euratom Joint Nuclear Research Center, Ispra, Italy between 1961 to 1967 is described. Included are studies of: fuel element fabrication and testing; instrumentation; thermal stress analyses of fuel elements; coolant channel design; safety of reactor components; heat transfer with organic coolants, liquid metals, and boiling water; nuclear electronics and electronic instrumentation; reactor electronics; computers; automation and control; and thermionic energy conversion. (L.C.L.)

**17646** ANALYSES OF ASYMMETRIC STIFFENED SHELL TYPE STRUCTURES BY THE FINITE ELEMENT METHOD. I. FLAT RECTANGULAR ELEMENTS. Zudans, Zenons (Franklin Inst. Research Labs., Philadelphia). Nucl. Eng. Design, 8: 367-79(Sept.-Oct. 1968).

A method of stress analysis based on flat rectangular finite elements is described. These elements, which are used to approximate the actual structure, can be composed of multiple stiffened orthotropic layers. The effects of structural stiffeners, elastic foundations, and surface and thermal loadings, as well as the dynamic mass matrix, are derived, for assumed continuous deformation modes within the panel, from the principle of virtual work. The application of the described solution method to the analysis of the cylindrical steel containment vessel for the LOFT reactor facility is illustrated. This structure has a large rectangular opening reinforced by box girders. (auth)

**17647** IMPROVEMENTS IN AND RELATING TO A HEAT EXCHANGER. Pouderoux, Pierre (to Commissariat a l'Energie Atomique). British Patent 1,145,226. Mar. 12, 1969. Priority date May 5, 1966, France.

A heat exchanger designed to transfer heat between 2 fluids which may react dangerously with each other is described. Water is vaporized by heat transfer from a liquid metal such as sodium. The heat exchanger consists of outer tubes disposed in parallel planes consisting of straight sections joined to each other by bends so as to form serpentive coils. The outer tubes are connected in parallel to inlet and outlet headers through which the first heat transfer fluid may be admitted and discharged. Each outer tube contains a number of inner tubes in which a secondary fluid flows. The inner tubes pass individually through the lateral wall of the outer tube and are connected to inlet and outlet headers. (F.S.)

**17648** DEVICE FOR IRRADIATING MATERIALS. Takehara, Yoshiaki (to Yoshizawa Namari Kogyo Co., Ltd.). Japanese Patent 1968-25079. Oct. 29, 1968. Filed June 20, 1966.

An irradiation device is described for biological and chemical experiments which has the following advantages: good protection from radiation in introduction or withdrawal of sample materials and elimination of remote operation. An irradiation room containing a radiation source is located within lead blocks which have air ventilation paths penetrating through the blocks. A shutter is located just above the irradiation room. Above the shutter is a larger room used in taking sample material out of the irradiation facility. The room has a door on its one side. A shielding plug moves between the irradiation room and the larger room and a sample holder is attached to the bottom surface of the plug. The shutter and the door cannot be opened at the same time. (NSA of Japan)

**17649** DEVICE FOR DRAWING OUT A SAMPLE IN A REACTOR HORIZONTAL EXPERIMENTAL-HOLE. Sato, Hisao (to Japan Atomic Energy Research Inst.). Japanese Patent 1968-29036. Nov. 28, 1968. Filed Feb. 29, 1964.

A device is described for removing a sample from a reactor irradiation hole that has the following advantages: simple construction, low production cost, and stable operation. The device is a handling rod of which the top end is a cylinder. The cylinder wall has inward circumferential protrusions which are produced by bending the wall at such positions. The open end, i.e., the opposite end from the handling rod, of the cylinder is inclined. When removing a sample capsule from a horizontal experimental hole, the handling rod is inserted into the hole and the capsule is caught within the cylinder. (NSA of Japan)

**17650** CAPSULE FOR IRRADIATING MATERIALS. Hirasawa, Yoshiya (to Mitsubishi Atomic Power Industry Inc.). Japanese Patent 1968-25078. Oct. 29, 1968. Filed June 6, 1966.

A method is proposed for constructing a double-walled capsule with the following advantages: simple construction, suitable for mass production; and good heat conduction from the inner to the outer container. The capsule consists of an outer cylindrical container; short cylinders, set within the outer container, each at either end of the container with axial outward protrusions that touch the inner surface of the container and axial cuts within the container into the cylinder wall; beam plates of Y cross-section running between the two short cylinders whose ends appropriately engage with the cut in the cylinder wall (the tip of the Y prongs touches the inner surface of the outer container); an inner sample container held in position by means of the base edge of the Y beam-plates. (NSA of Japan)

**17651** REMOTE AND AUTOMATIC SAFETY DEVICE. Kinoshita, Masahiro (to Osaka Prefecture). Japanese Patent 1968-26680, Nov. 15, 1968. Filed Feb. 21, 1964.

A procedure is proposed whereby the safety control for irradiation facilities, freezers, safes, etc. can be done in a remote and automatic way. A person entering an irradiation room carries with him a device for emitting high-frequency wave signals. The doors in the path of it are opened only by the signals. The same signals are also caught by a nearby antenna, and then are sent to a receiver. The receiver governs the operation of an irradiation room, including the opening or closing of the doors. (NSA of Japan)

**17652** VACUUM HOT-PRESS FOR TOXIC MATERIALS. Kelly, J. W. (Australian Atomic Energy Commission Research Establishment, Lucas Heights). J. Phys., E (London), 2: 369(Mar. 1969).

A small vacuum hot-press is described which is easily operated and maintained within a Harwell MK II glove box. The press incorporates a sliding vacuum seal. (auth)

**17653** DEVICE FOR INTRODUCING AND WITHDRAWING A SAMPLE MATERIAL IN THE IRRADIATION ROOM. Ajioka, Katsushige (to Kimura Entetsu Kagaku Kikai Co., Ltd.). Japanese Patent 1968-29039. Nov. 28, 1968. Filed Apr. 4, 1964.

A method is proposed by which an irradiation sample can be introduced into the irradiation space or withdrawn from it through the shielding wall. In an opening through the shielding wall, a horizontally tapered rotating block is installed. A hollow is cut on the one side opening horizontally. The sample material is placed in the hollow. By rotating the block, the sample material can be brought either into the irradiation space or the adjoining space. (NSA of Japan)

**17654** FUEL ELEMENT FOR MEASURING PURPOSES. Sasaki, Masayoshi (to Hitachi Ltd.). Japanese Patent 1968-26673, Nov. 15, 1968. Filed July 7, 1965.

A method is proposed for positioning a measuring wire within a U-tube running along a fuel element. The U-tube can also be used as a pneumatic tube. At the bottom of the U-tube, the inside surface is inclined and a short horizontal protrusion held by a spring is set within the bent part. A small iron sphere, suspended by a string, is lowered in the tube with a measuring wire attached to the string. After reaching the bottom, the sphere and the spring are pulled up the other tube of the U-tube. (NSA of Japan)

**17655** COMPACT DEVICE FOR LOW TEMPERATURE NEUTRON IRRADIATION OF DEFORMED SPECIMENS UNDER A DEFINED TENSILE STRESS. Mughrabi, H. (Max-Planck-Institut fuer Metallforschung, Stuttgart). J. Phys., E (London), 2: 351-2(Mar. 1969).

A device is described with which tensile test specimens may be irradiated under a well-defined tensile stress with fast neutrons in low temperature irradiation facilities in order to stabilize the dislocation arrangement present in the stress-applied state. (auth)

**17656** NUCLEAR DESALINATION OF SEA WATER AND FERTILIZER MANUFACTURE. Alagarsamy, S. R.; Lakshminarayana, J. S. S.; Bopardikar, M. V. (Central Public Health Engineering Research Inst., Nagpur, India). Technology (Sindri), 5: 130-41(Apr.-June 1968).

Single- and dual-purpose reactors for use in desalting seawater, are described and the advantages of the two processes are compared wtih particular reference to Bombay's power and water supply. The studies carried out by Burns & Roe of New York for a 100 Mgd plant, (single-purpose) and Kaiser Engineers for a 100 Mgd dual-purpose plant 150 Mgd by Bechtel and Grace process for by-product fertilizer recovery plant have been extensively quoted for cost, operating expenditure, and annual revenue. Unlike other countries, today India needs fertilizers for food self-sufficiency and has proposed to put up additional fertilizer plants. The cost of a triple-purpose plant—which is India's need today—for water, power and fertilizer is estimated and is a prima facie case of economic feasibility. Technical feasibility is already established by the above-mentioned three consulting engineers' firms. At present Bombay is supplied 220 Mgd water from Tansa, Tulsi and Vaitarna through over 70 miles surface-laid 6 to 9' diameter steel mains—the crucial point being Kassuli bridge—over which all these pipes pass. Power is supplied from Koyna. In the context of present-day international situation, it is essential to prove an independent source of water for Bombay, which would also meet the vagaries of monsoons. (auth)

**17657** ENGINEERING AND ECONOMICS OF FOOD IRRADIATION. Josephson, Edward S.; Brynjolfsson, Ari; Wierbicki, Eugen (Army Labs., Natick, Mass.). Trans. N. Y. Acad. Sci., 30: 600-14(Feb. 1968).

Gamma radiation from a $^{60}$Co source and electrons produced by an electron linear accelerator are the two types of ionizing radiation most extensively used during the past 5 yr in the Army's high-dose radiation preservation of foods program. The γ radiation from $^{60}$Co are deeply penetrating and can be used, without inducing radioactivity, to sterilize packages of food with thicknesses up to 12 in. The penetration of electrons is dependent upon their energy, but at energies above 12 MeV they can induce minute amounts of radioactivity in the food. Electrons of 10-MeV energy were used to avoid induced radioactivity. This has limited the thickness of food packages that can be preserved by irradiation with the electron source to 1¼ in. All possible ions and free radicals of O and H have been reported. These ions and radicals may interact with each other, producing both inert and reactive compounds, and with other components in foods. By reducing the temperature at which radiation is applied, it has been possible to slow the release of free radicals which appear to be responsible for some off-flavor problems. By reducing O tension, oxidative effects can be diminished or eliminated. Liquid N is consumed when it is used as coolant, due to different heat conduction losses, product cooling, and radiation heating. The radiation heating of the product, the container of the product and the conveyor in the radiation cell is 2.4 cal/g Mrad. (BBB)

**17658** COMPARISON OF CALCULATED AND MEASURED STRAINS IN THE OLDBURY CONCRETE PRESSURE VESSELS. Irving, J.; Carmichael, G. D. T. (Central Electricity Generating Board, Berkeley, Eng.). J. Brit. Nucl. Energy Soc., 8: 60-4(Jan. 1969).

The finite element method of analysis is used to calculate the changes in strains and deflections of the Oldbury vessel R1 during proof pressure test. Good agreement is shown between predicted and measured values when the predicted strains are calculated using experimentally determined values of Young's modulus and Poisson's ratio. Allowance is made for the presence of standpipe penetrations in the top cap of the vessel by including a reduced elastic modulus in the analysis of the penetrated region. Additional results are presented comparing the deflections of an 1/8th scale model of the Oldbury vessel with those obtained by the finite element method and by a finite difference analysis. It is concluded that the analysis by computer of an idealized continuum is sufficiently accurate for elastic design purposes, provided that the concrete material properties are known. (auth)

**17659** TESTING STATION FOR NUCLEAR REACTOR CONTROL ROD MECHANISMS AND FUEL ELEMENTS. Lhoir, J.; Sonnet, W. ACEC (Ateliers Constr. Elec. Charleroi) Rev., No. 3-4, 23-33(1968).

The pressurized water testing station was built on a shared expense basis with a view to development of prototypes and to the checking of the performance and characteristics of control rods, their followers and mechanisms, and of fuel elements for nuclear reactors. This station has therefore been designed to reproduce the actual thermodynamic operating conditions in a pressurized water reactor. The station buildings and their functional design, the main equipment such as the test channel, the pressurizer, the main cooler, the monitor and charging exchangers and the circulation and charging pumps are described. One section is specially devoted to the systems for metering, controlling, and protection of the loop. (auth)

**17660** PRACTICAL ASPECTS OF SPACE SIMULATION FACILITY OPERATIONS. McKinney, H. F.; Dutton, R. A. pp 203-10 of IES/AIAA/ASTM Third Space Simulation Conference. Mt. Prospect, Ill., Institute of Environmental Sciences, 1968.

From 3rd Space Simulation Conference, Seattle, Wash. See CONF-680947.

During operation of the more than 80 vacuum systems and associated test equipment, many problems have been encountered. Practical solutions are presented to selected problems involving vacuum pumps, seals, feedthroughs, viewports, and other associated equipment. Contamination problems and cleaning procedures are reviewed. Examples are given of simple modifications which permit the use of existing equipment for special test requirements. These requirements have included reproducing the pressure-time history of a launch profile, flammability testing of electrical wiring in a spacecraft atmosphere, production and measurement of forces in vacuum, and reliable operation of unattended long-duration vacuum tests. (auth)

**17661** SPACE SIMULATION FACILITY FOR IN-SITU EVALUATION OF SPACECRAFT MATERIAL DEGRADATION. Clifford, D. W.; Schmitt, R. J. pp 157-63 of IES/AIAA/ASTM Third Space Simulation Conference. Mt. Prospect, Ill., Institute of Environmental Sciences, 1968.

From 3rd Space Simulation Conference, Seattle, Wash. See CONF-680947.

Healing or recovery processes have been shown to exist when certain materials are removed from the simulated space environment for evaluation. These phenomena have been primarily

associated with the optical degradation of thermal control coatings but have also been exhibited in certain physical properties of other materials. A description is presented of the design and performance of a space simulation facility incorporating cryogenic temperature control, ultrahigh vacuum, and space radiation sources with the added capability of incorporating a variety of in-situ evaluation techniques. Emphasis has initially been placed on the current problems of developing adequate thermal control surfaces for prolonged space missions and, operating in conjunction with the real-time test facility at McDonnell, developing valid accelerated radiation testing methods for thermal control materials. Consequently, the system now incorporates an integrating sphere, coolant reservoir, and the necessary optics for in-situ reflectance measurements. However, by changing flanges and pass-throughs, the system can provide in-situ mechanical evaluation such as lap shear, tensile, and compression tests. The in-situ techniques are emphasized in the description of the facility design and performance. (auth)

**17662** SINTERING FURNACES FOR HIGH-MELTING METALS. Stolarz, Stanislaw Rudy i Metale Niezelaz., 13: 597-603 (Nov. 1968). (In Polish).

The sintering of products manufactured by powder metallurgy and the construction and general characteristics of high-temperature sintering furnaces are discussed. The sintered products are either resistance heated by direct transmission of electric current or are indirectly heated by a high-temperature heating element. These furnaces are generally operated in vacuum or in protective atmospheres and are used for pressure welding of high-melting metals such as W, Mo, Ta, Nb. (auth)

**17663** 60 kV SPARK GAP (Engineering Materials). (Los Alamos Scientific Lab., N. Mex.). (CAPE-1846).

8 drawings.

A 60 kV start spark gap with a crowbar spark gap attached is described. The spark gap is used with a 1.85 μf, 60 kV capacitor for capacitor bank discharge in the Sherwood Project. The crowbar gap is used to clamp the load current when the energy has been transferred into the load. (For details see TID-4100, Suppl. 51.) (F.S.)

**17664** SUB-MASTER TRIGGER GAP (Engineering Drawings). (Los Alamos Scientific Lab., N. Mex.). (CAPE-1847).

10 drawings.

A sub-master trigger gap used to trigger fifty-four 60-kV spark gaps (see CAPE-1846) is described. The trigger gap uses coaxial cable as low inductance energy storage capacitors. This equipment is used in thermonuclear research in the Sherwood Project. (For details see TID-4100, Suppl. 51). (F.S.)

**17665** LIQUID RESISTOR (Engineering Materials). (Los Alamos Scientific Lab., N. Mex.). (CAPE-1848).

1 drawing.

A liquid resistor using a dilute mixture of distilled water and $CuSO_4$ is described. The resistor is designed to absorb 720 kJ of energy from a capacitor bank for three shots spaced five minutes apart without raising the temperature of the liquid above the boiling point. The capacitor bank is used in a thermonuclear experiment in the Sherwood Project. (For details see TID-4100, Suppl. 51). (F.S.)

**17666** APPARATUS FOR THE PRODUCTION OF HEAVY WATER. Rostaing, Michel (to Commissariat a l'Energie Atomique). U. S. Patent 3,431,080. Mar. 4, 1969. Priority date Nov. 15, 1963, France.

Heavy water is produced by the countercurrent isotope exchange process in two exchange zones at different temperatures between a current of liquid water which is the deuterium source and a current of the $H_2S$ gas which is the exchange medium. High pressure superheated steam from a boiler drives a steam turbine which is operatively connected to drive the blower for circulating the $H_2S$ gas and to drive an electrical alternator. Expanded steam leaving the turbine passes in parallel flow through a pair of heat exchangers and is then returned to the boiler for reheating. (Offic. Gaz.)

**17667** COOLING WATER INTAKES AT WYLFA POWER STATION. Chapman, E. J. K.; Gibb, F. R.; Pugh, C. E. Proc. Inst. Civil Eng. (London), 42: 193-216(Feb. 1969).

The cooling water intakes and sea shafts are situated on the rocky sea bed off the northern coast of Anglesey. Because of the rugged conditions and exposure of the site to northerly gales, each intake was designed as an underwater structure consisting of an anti-vortex canopy, coarse screen, and dewatering cap. The construction was done underwater, using large precast concrete blockwork set and fixed by divers. In order to provide both permanent and construction access to the intakes, a tubular steel jetty and headworks structure was constructed from the shore by overhand methods. This involved drilling holes 15 ft deep into the rocky sea bed for the ends of the piles, which were grouted into the sockets. After the intakes had been constructed the sea shafts were raised from the tunnels below and connected into the intakes. The lining of the shafts with in situ concrete was carried out in the dry by working from the tunnels while the mouths of the intakes were covered by the dewatering caps. The work of constructing two intakes and two shafts was carried out during one six months' summer period after the jetty and headworks had been completed. (auth)

**17668** SPACE RADIATORS OPTIMIZED AS STRUCTURAL ELEMENTS. Cockfield, Robert D. (General Electric Co., Schenectady, N. Y.). Space/Aeronaut., 50: 86; 88; 90(Oct. 1968).

The design of future large spacecraft radiators used for heat rejection, particularly in vehicles for missions that can only be performed by nuclear-powered electric propulsion, is considered. A case in point might be a Jupiter probe with a 300-kW(e) nuclear powerplant. It is typical of such a powerplant that, for every kW of electricity it generates, 10 kW of heat must be rejected through the radiator. For a spacecraft of this class, the radiator is the dominant design element in both size and weight. The crucial question is whether a large spacecraft radiator can be designed to satisfy both structural and thermal requirements in an efficient fashion. Recent studies show that this is possible. The optimum design point for a structural radiator, which combines minimum weight with maximum density lies at the intersection of the structural boundary with the line of area-limited optima. In comparison with the nonstructural minimum-weight point, this design point will mean a reduction in tube spacing, an increase in fin thickness, and therefore an increase in radiator weight. In the case of a beryllium-and-stainless-steel radiator with a heat rejection capability of 5 MW and a meteoroid survival probability of 0.95 for 15,000 hr, the structural requirements increase the minimum weight of the radiator from 3880 to 4110 lb. (BBB)

**17669** VACUUM FURNACES AND EQUIPMENT FOR PRODUCTION OF NUCLEAR FUELS. Honorat, R. Ind. At., 12: No. 11-12, 49-52(1968). (In French).

Vacuum furnaces and ovens and auxiliary devices for the production of nuclear fuels, developed and constructed by the Societe Alcatel, are described. The devices considered are the vacuum induction furnace, rocking crucible induction furnace, induction furnace in air, vacuum induction ovens and furnaces, cooling under controlled atmosphere, thermofluid circulation oven, muffle furnaces and ovens under vacuum and controlled atmosphere, and pumps. Some of these devices are illustrated. (J.S.R.)

**17670** GRAPHO-ANALYTICAL SUBSTANTIATION OF PLANNING ELEMENTS IN ROOMS FOR MOBILE GAMMATHERAPY. Stavitskii, R. V. (Central Inst. for Graduate Medical Studies, Moscow). Med. Radiol., 14: No. 2, 48-53(Feb. 1969). (In Russian).

A technique is proposed for controlling protective devices of labyrinths and rational location of gammatherapeutic apparatus with the aid of liminal curves (single scattering) and surface (two-fold scattering). (auth)

**17671** IMPROVEMENTS IN AND RELATING TO HEAT EXCHANGERS. (to Sulzer Brothers Ltd.). British Patent 1,146,012. Mar. 19, 1969. Priority date Mar. 12, 1965, Switzerland.

A heat exchanger for the exchange of heat between two mediums is described. The heat exchanger is located in a flow path of one of the mediums such as the coolant in a reactor. The heat exchanger consists of a number of parallel-connected heat exchange units placed side by side with gaps between adjacent units. Each unit includes at least one flow passage for one medium with the coolant medium flowing around the other. Baffles are spaced to restrict the flow of the coolant so that the pressure of the two mediums at adjacent locations are the same. (F.S.)

**17672** FUEL ASSEMBLY FOR NUCLEAR REACTORS WITH FUEL RODS POSITIONED BY SPRINGS CARRIED BY A GRID. Glandin, Constan (to Allmaenna Svenska Elektriska Aktiebolaget). U. S. Patent 3,431,171. Mar. 4, 1969. Priority date June 3, 1964, Sweden.

The rods in a nuclear reactor fuel assembly are positioned by a grid formed of rigid spacers extending longitudinally. The rods have elongated springs also extending longitudinally which engage the rods at angularly spaced points to position the rods. (Offic. Gaz)

## Heat Transfer and Fluid Flow

*Refer also to abstracts 17627, 17643–17645, 17647, 17668, 17671, 17878, 18189, 18190, 18262, 18648, and 19587.*

**17673** (CEA-CONF-1097) RELATION BETWEEN THE STRUCTURE OF THE TWO-PHASE LAYER NEAR THE HEATED WALL AND THE MECHANISM OF EXCHANGE. Semeria, R. (Commissariat a l'Energie Atomique, Grenoble (France). Centre d'Etudes Nucleaires). [nd]. 23p. (In French). (CONF-680943-1). Dep.

From International Conference on Mass and Heat Transfer in Turbulent Boundary Layer, Herceg Novi, Yugoslavia.

The cooling of a heated wall by boiling of a pure liquid is analyzed by considering first the movements of liquid around bubbles being formed and displaced on the wall. From this are deduced the various mechanisms responsible for the excellent thermal exchange between the wall and the boiling liquid so long as the wall remains wet. The evolution of the two-phase structure near the wall was found to be a function of the density of the thermal flux, the mean temperature of the liquid, and the rate of circulation, by analyzing especially the instantaneous local temperature of the fluid given by a microthermocouple. It was found that the definitive drying of a portion of the wall (thermal flux of film boiling) is conditioned not only by the hydrodynamics of the two-phase structure but also by the thermal properties of the wall itself; in particular, the thermal flux of film boiling on the thin walls can be very much less than the critical flux on thick walls. The analysis of the evolution of a transitory localized drying makes possible the explanation of this difference in behavior. (tr-auth)

**17674** (CEA-CONF-1109) REVIEW OF STUDIES OF RAPID HEAT TRANSFER AND SODIUM BOILING CURRENTLY IN PROGRESS IN FRANCE. Millot, J. P. (Commissariat a l'Energie Atomique, Cadarache (France). Centre d'Etudes Nucleaires). Oct. 25, 1968. 5p. (In French). (CONF-681043-1). Dep.

From 4th Conference of Committee on Reactor Safety Technology, Paris, France.

The thermodynamic effects creating an explosive phenomenon during a sizable fusion of a reactor core are being studied under two different aspects: the hammer effect at the CABRIOLE loop and the thermodynamic yield of the explosion caused by a mixture of fused metal or oxide with the coolants at Grenoble and the SODERA. The CABRIOLE studies have shown the existence, under certain conditions, an an unstable vapor film. Sodium boiling studies at Grenoble have shown that the maximum superheating occurs at 100°C and that the effects of the friction on the walls and of vibrations are zero. (J.S.R.)

**17675** (CTC-7) STUDY OF VORTEX FLOW. Farris, G. J.; Kidd, G. J. Jr.; Lick, D. W.; Textor, R. E. (Union Carbide Corp., Oak Ridge, Tenn. Computing Technology Center). Mar. 17, 1969. Contract W-7405-eng-26. 91p. Dep. CFSTI.

An experimental and theoretical examination of the interaction of a vortex with a stationary surface is presented. The flow field studied experimentally was produced by a fluid flowing radially inward through a pair of concentric, rotating, porous cylinders that are perpendicular to, and in contact with, a stationary flat surface. A numerical procedure is provided for the solution of the steady-state Navier-Stokes equations for the flow of a viscous, incompressible fluid between two such cylinders, with or without flow through the cylinders in the radial direction. Solutions are displayed for a range of tangential Reynolds numbers from 0 to 300 and a range of radial Reynolds numbers from 0 to −13. The general validity of the numerical method is demonstrated by the agreement between numerical and experimental results. Examination of the numerical results over a wide range of parameters shows that the entire flow field is very sensitive to the amount of radial flow, especially at the transition from no radial flow to some finite value. Results of several numerical experiments performed to improve the efficiency of the numerical method are given, and the feasibility of the use of the method for the study of the hydromagnetic stabilization of vortex flow problems is demonstrated. Recommendations for future investigation of vortex problems are made. (auth)

**17676** (LA-4109) QUARTERLY STATUS REPORT ON THE SPACE ELECTRIC POWER R AND D PROGRAM FOR THE PERIOD ENDING JANUARY 31, 1969. PART I. (Los Alamos Scientific Lab., N. Mex.). Feb. 26, 1969. Contract W-7405-eng-36. 9p. Dep. CFSTI.

Equations used in heat pipe design are presented including an equation to show the effects of vapor density and velocity on heat transfer. Sonic limitations for Cs, K, Li, and Na heat pipe working fluids are given. Compatibility evaluation of the Re–Ag heat pipe at 2000°C was terminated because of a leak in the evaporator section of the pipe. High purity Re when used in a two metal system will operate satisfactorily at 2000°C in excess of 300 hrs without detectable entrainment between the metals. If high purity W is employed in the W–Ag system, the system has the same capability. In the Re–W–Ag system, in which W was used as the wick mass transport of W was found. A new Hg pipe was built, loaded, and tested for 4,600 hr operation at 300°C. A modified variable-spacing diode system test indicated some degree of local thermodynamic equilibrium. Data were insufficient to determine the magnitude of departure from equilibrium. Electron temperatures did not exceed 2800°K despite the high current densities and close spacings. (F.S.)

**17677** EMPIRICAL FORMULA ON THE TUBES BURN-OUT BY STATISTICAL TREATMENT. Kagawa, Tatsuo (Nippon Atomic Industry Group Co., Ltd., Tokyo); Yanai, Ryoichi. Collect. Lect., Jap. Heat Transfer Symp., 5th, 217-20(May 1968). (In Japanese).

With light water cooled reactors, the design of a safe and high-efficiency reactor core must be made. Burnout experiments were carried out on a group of tubes. With the lack of suitable theoretical and empirical formulas, the design values were obtained experimentally. An attempt was made to obtain an empirical formula for tube burnout utilizing available data. The nature of burnout heat flux for the tubes was determined. It was concluded that an improved formula, applicable in the actual design, should be obtained by collecting more data. (NSA of Japan)

**17678** DEVICE FOR PRODUCING VOIDS. Hachiya, Yuuki (to Nippon Electric Co., Ltd.). Japanese Patent 1968-25070, Oct. 29, 1968. Filed May 18, 1966.

A device is described for producing voids artificially in the coolant water to measure void coefficients in reactors. The advantages of the method are the possibility of freely changing the void distribution, the size of voids, the amount of void and the integrity of the actual neutron absorption cross-sections. The device consists of a tube through which coolant water runs; a double-walled tube, surrounding the coolant tube; many small holes penetrating the wall of the inner tube, and the same holes penetrating the inner wall of the outer tube. The double-walled tube is filled with pressurized air. One of the tubes is rotatable, relative to the other. When holes through the inner-tube wall coincide with the holes in the double-wall tube wall by the rotation, air is ejected into the coolant water in the form of voids. (NSA of Japan)

**17679** ON THE ARRANGEMENT OF BURN-OUT HEAT FLUX DATA. Nagai, Masayuki; Masuda, Shinichiro (Hitachi Ltd., Tokyo). Collect. Lect., Jap. Heat Transfer Symp., 5th, 213-16 (May 1968). (In Japanese).

Burn-out is important in boiling water reactors in connection with the increase in core power density. It is necessary to estimate burnout heat fluxes with high accuracy. In the reactor, there exists an axial power distribution along the fuel rods while experimental data so far obtained are for uniform heating. Such data available for tubular bodies were arranged for prediction of the burnout heat fluxes, taking into account the nonuniform heating distribution; the factors included the length of boiling, parametric effects and other burnout conditions. The results were found to be satisfactory for the purpose. (NSA of Japan)

**17680** RADIANT HEAT TRANSFER WITH SCATTERING. Pomraning, G. C. (Gulf General Atomic Inc., San Diego, Calif.). Int. J. Heat Mass Transfer, 12: 81-93(Jan. 1969).

The transport equation appropriate for radiant heat transfer calculations and including the effects of photon scattering is discussed. It is shown that for low temperatures and photon energies ($\ll$0.5 MeV) the scattering of photons from a Maxwellian gas of free electrons can be described by a relatively simple second order differential operator. A diffusion approximation, employing the same description of scattering, is derived from the transport equation. The qualitative aspects of the solution of both the transport and diffusion equations are discussed in the limit of zero electron temperature. In particular, it is shown that in this limit this description of scattering gives the proper behavior of only a decrease in photon frequency upon scattering. This is in contrast to previous attempts to represent the scattering process by a differential operator, which led to the physically incorrect result of some increase in frequency due to scattering from electrons at rest. (auth)

**17681** POOL BOILING HEAT TRANSFER WITH MERCURY AND MERCURY CONTAINING DISSOLVED SODIUM. Lee, Y. (Chalk River Nuclear Labs., Ont.). Int. J. Heat Mass Transfer, 11: 1807-21(Dec. 1968).

Mercury was boiled from Type 304 stainless-steel horizontal cylindrical heaters of $\frac{3}{4}$ in. dia with the system pressure varied from 24 to 1170 mm Hg, pool depth from 7 to 34 cm and Na concentration from 0 to 0.232 wt%. Increasing system pressure increased the heat-transfer rate for a given condition in pure Hg and Hg containing more than 0.041% Na; the inverse effect was observed at a Na concentration of 0.0036%. The effect of pool depth was insignificant, especially at high system pressure; local liquid

temperatures exceeding the surface saturation value were detected only at great pool depths at low system pressure. Immersion up to 8 weeks had little effect on the Type 304 S.S. mirror-finish heating element. Increasing Na concentration had an adverse effect on the heat-transfer coefficient up to a certain level and then the trend changed. Up to 0.232 wt% Na in Hg did not raise the heat-transfer rate above the comparable value for pure Hg. Boiling results were found reproducible on many spot checks after an initial period of operation of the apparatus. (auth)

**17682** OUTFLOW OF SUPERSATURATED WATER THROUGH SHORT PIPES. Narisi, Hideki (Ship Research Inst., Tokyo). Collect. Lect., Jap. Heat Transfer Symp., 5th, 237-40(May 1968). (In Japanese).

An experimental study on the outflow of supersaturated water through a short pipe is reported. Formulas were derived for the flow rates, under the conditions of inlet pressure and temperature, outlet pressure, and pipe length. Consideration was given to the so-called sharp-edge orifice and the relation of in-pipe pressure and pipe length was obtained. The outlet critical conditions as a function of the degrees of supersaturation, void ratio, and pressure need to be found. (NSA of Japan)

**17683** PHENOMENON OF AN UNSTABLE FLOW IN THE FORCED-FLOW VAPORIZATION PIPES. Akagawa, Koji; Sakaguchi, Tadashi (Kobe Univ., Japan). Collect. Lect., Jap. Heat Transfer Symp., 5th, 249-52(May 1968). (In Japanese).

The phenomenon of an unstable flow in the forced flow vaporization pipes with boiling, such as in the reactor cooling system, is important in the reactor design due to burnout and reactor power fluctuation. Experiments were made on the problem for long pipes and the mechanism was studied. It was found that in the positive slope region of the characteristic pressure loss-flow rate curve where the flow is usually considered to be stable, there occurs a pulsed unstable phenomenon with counter flow when the pipe outlet dryness is high. For long piping, an unstability of the deviation-type is predominant in the negative slope region of the characteristic pressure-loss curve. (NSA of Japan)

**17684** FLOW ABOUT A GROWING SPHERE IN CONTACT WITH A PLANE SURFACE. Witze, C. P.; Schrock, V. E.; Chambre, P. L. (YUniv. of California, Berkeley). Contract AT(11-1)-34. Int. J. Heat Mass Transfer, 11: 1637-52(Nov. 1968).

A solution is presented for describing the potential flow pattern in a semi-infinite liquid surrounding a sphere that is growing while remaining tangent to a plane solid surface. An exact integral representation of the solution for the potential distribution is given. A simple analytic representation for the integrand was chosen to replace the exact form and thus provide closed form analytic results for both the potential and velocity distribution. Properties of the flow field are examined. The total kinetic energy of the fluid agrees well with the result of an earlier but less detailed calculation by Shiffman and Friedman. For one specific growth law the pressure distribution was evaluated and used to form a new criterion for detachment of the sphere from the surface. The solution should find application in boiling bubble dynamics, underwater explosions and cavitation studies. (auth)

**17685** THERMAL TURBULENCE CHARACTERISTICS IN SODIUM–POTASSIUM. Hochreiter, L. E.; Sesonske, Alexander (Purdue Univ., Lafayette, Ind.). Int. J. Heat Mass Transfer, 12: 114-8(Jan. 1969).

Measurements of the turbulent temperature fluctuations in the flow field are reported, and are compared with existing velocity and temperature fluctuation data in other fluids to provide some insight into the turbulence structure. The experimental equipment, which is described, included a 56 in. long heated test section of 1.0 in. ID by $\frac{1}{8}$ in. wall. Temperatures were measured by specially designed fast response chromel-P/constantan thermocouples. (UK)

**17686** THERMAL SCALING OF BOLTED JOINTS. Shih, C. (Martin Marietta Corp., Denver). pp 176-83 of IES/AIAA/ASTM Third Space Simulation Conference. Mt. Prospect, Ill., Institute of Environmental Sciences, 1968.

From 3rd Space Simulation Conference, Seattle, Wash. See CONF-680947.

Thermal scaling of bolted joints was carried out. Sealing processes were applied to (1) effects of different material properties, (2) effects of size variation, and (3) the effects of having a high thermal conductivity grease between the surfaces of contact. Experimental values of the ratio of thermal conductance of the model to that of the prototype compared favorably with the analytical ratios. However, it should be well understood that even though the task was successful within the scope of the original objective, the criteria used were applicable for bolted joints of similar geometry of the type tested. The thermal conductance of a bolted joint is greatly influenced by the arrangement of the bolts and the boundary conditions. It is hard to visualize at present how a generalized scaling criterion can be formulated. It is possible, after more extensive research into this area, a rational general principle can be obtained. As a first step a more clear understanding should be obtained of the pressure distribution between the surfaces of contact under various bolt arrangements. (auth)

**17687** DERIVATION OF STEAM FRACTION DYNAMICS EQUATION UNDER SURFACE BOILING CONDITIONS IN STEAM GENERATING CHANNELS. Plyutinskii, V. I.; Fishgoit, L. L. At. Energ. (USSR), 25: 474-9(1968). (In Russian).

Published experimental data on surface and pool boiling in steam generating channels were analyzed to develop a method for calculating non-stationary values of steam fraction for different channel configurations and different distributions of heat flow along the channel length (one-dimensional model). The assumptions used also permit calculation of steam fraction values for surface and pool boiling in steady state conditions. The calculated values of steam fraction are in good agreement with experimental data. (auth)

## Isotope Technology

*Refer also to abstract 17657.*

**17688** (AI-AEC-12776) LARGE RADIOISOTOPE HEAT SOURCE CAPSULE (LRHSC). Sixth Quarterly Progress Report, October–December 1968. (Atomics International, Canoga Park, Calif.). Jan. 30, 1969. Contract AT(29-2)-2338. 60p. Dep. CFSTI.

Progress on the development of a large radioisotope heat source capsule capable of operating in a space environment at a surface temperature of about 2000°F for five years or more is reported. The objective of the present phase of the program is to design, fabricate, test and evaluate a test capsule. The test program includes evaluation of chemical compatibility, thermal cycling, adherence of coatings, capsule creep, capsule impact and capsule earth burial. (F.S.)

**17689** (ALO-2510-4) SILICON GERMANIUM THERMOELECTRIC MATERIALS AND MODULE DEVELOPMENT PROGRAM. 4th Quarterly Report, October 1–December 31, 1968. (Radio Corp. of America, Harrison, N. J. Special Electronic Components Div.). Contract AT(29-2)-2510. 77p. Dep. CFSTI.

Efforts devoted to improvement of SiMo hot shoe materials and refinement of fabrication and bonding techniques are reported. The development of high-conductance alternate hot shoe materials for use in primary launch environments or in vacuum at 900°C is described. Preparation and bonding techniques for SiGe alloys were investigated. The determination of electrical stability of thermoelectric materials as a function of time, temperature, and environment is reported. The design and operating parameters of the SiGe-thermocouple, module, and converter configurations are reviewed. Alternate hot shoe materials of SiC-coated graphite and SiC are being evaluated. Compositional uniformity for SiGe alloys higher than 63.5 at.% Si has been established. A Reference Converter and a 5-watt converter have operated at ~1000°C hot shoe temperatures without significant change in power output or efficiency. A device efficiency of 6.6% for the full converter has been projected at a hot junction of 1000°C in comparison with 5.4% efficiency measured on the MIN-K insulated converter. An analysis of radiantly coupled cascade systems was completed. (J.C.W.)

**17690** (CEA-CONF-1076) GAMMAGRAPHY WITH LOW-ENERGY PHOTON EMITTERS. Verant, J. F. [nd]. 12p. (In French). (CONF-680606-14). Dep.

From Symposium on Nondestructive Testing and Control in the Field of Nuclear Metallurgy and Technology, Saclay, France.

The use of $^{170}$Tm, $^{125}$I, $^{147}$Pm, $^{169}$Yb, $^{155}$Eu, and $^{210}$Pb for gammagraphy was studied using Al A5 plates. The results showed that $^{170}$Tm, $^{169}$Yb, and $^{155}$Eu gave an image of average quality while $^{125}$I gave a good quality image, and $^{147}$Pm a very good quality image. The exposure time for $^{170}$Tm and $^{169}$Yb are good, that for $^{155}$Eu is much longer than that of $^{170}$Tm. The period of $^{155}$Eu is much longer however, which is advantageous. The exposure times for $^{147}$Pm and $^{125}$I are much longer. (J.S.R.)

**17691** (COO-1239-18) DIFFRACTOMETRY WITH $^{55}$Fe AND BETA EXCITED X-RAY SOURCES. Final Report. Preuss, Luther E.; Toothacker, William S.; Bugenis, Claudius K. (Edsel B. Ford Inst. for Medical Research, Detroit, Mich. Div. of Nuclear Spectroscopy and Radiation Physics). 1968. Contract AT(11-1)-1239. 75p. Dep. CFSTI.

The beta excitation mechanism produces a polychromatic spectrum which carries the characteristic radiation of the target material. Electron capture isotopes, such as $^{55}$Fe, produce a

monochromatic spectrum and are characterized largely by the K radiation of the decay product, although other characteristic x rays are also produced. The energies of these photons are equivalent to those commonly used in x-ray diffraction analysis. Preliminary studies using a simple gross assay scheme common to ordinary diffractometry provided negative results. A spectroscopic approach was made in the second step (plus the use of improved sources) and the entire spectrum elucidated with special attention placed in the region of energy of the diffracted beam. Computations were made for diffraction prediction for a small $^{55}Fe$ source. Theory showed that, for the diffractometer used, powder samples would provide rates of the order of 10 cpm; for single crystals (LiF, NaCl, quartz) a few thousand cpm under ideal conditions could be expected at the detector. Good correspondence was found with theory in experiments done with LiF and NaCl powder and single crystals, using a small $^{55}Fe$ source. A 250 mCi $^{147}Pm$ Cu source was tested. A commercial Norelco diffractometer was adapted and data were taken which allowed comparison with standard analytical x-ray tube studies. Resolution was good with $^{55}Fe$ but intensities for the diffracted beam were substantially reduced. An improved 200 mCi $^{55}Fe$ source was introduced and an automated run made with the LiF single crystal. A recognizable pattern was produced—possibly the first motorized diffraction run on such an x-ray source in a standard diffractometer. $^{55}Fe$ technology is sufficiently advanced to produce diffracted main beams on single crystals (LiF) of $1 \times 10^4$ cpm, and about $2 \times 10^{-2}$ of this for powder. (J.C.W.)

**17692** (MMM-3691-34) SNAP-21 PROGRAM, PHASE II. THERMOELECTRIC GENERATOR PERFORMANCE EVALUATION AND DESIGN DESCRIPTION. Wickenberg, R. F.; McArthur, W. A.; Pettman, R. E. (Minnesota Mining and Mfg. Co., St. Paul. Electrical Products Group). June 27, 1968; Revised Aug. 1, 1968; Revised Nov. 29, 1968. Contract AT(30-1)-3691. 264p. Dep. CFSTI.

Design, development, fabrication, and performance evaluation testing of thermoelectric generators was conducted to evaluate the relative merit of two SNAP-21 candidate designs. Seven development generators were tested and met or surpassed all design requirements. These generators differed from the Phase I design in the areas of leg manufacturing process, hot junction electrical contacting technique, and cold end configuration. The following recommendations for the final SNAP-21 design configuration were made: ball and socket cold end configuration, beryllium oxide (BeO) followers, nickel plated cold caps, soft nose P-type hot end, pressed/green-bonded/sintered leg fabrication, Min-K 1301 thermal insulation, and xenon backfill gas. The 10-watt final design based on these recommendations will meet design specifications under all required system performance conditions. (auth)

**17693** (MMM-3824-30) SNAP-23A PROGRAM, PHASE I. THERMOELECTRIC CONVERTER DEVELOPMENT PROGRAM. Quarterly Report No. 8, October 1–December 31, 1968. (Minnesota Mining and Mfg. Co., St. Paul. Electrical Products Group). Jan. 31, 1969. Contract AT(30-1)-3824. 113p. Dep. CFSTI.

Testing of the PMC-1B converter consisted of initial performance verification, stability conditioning, and long-term operation. Design criteria for PMC-2 included investigations of materials for converter enclosure. A review of corrosion test data indicates that the existing 304 stainless steel used for the converter case may incur stress corrosion damage and pitting when placed in a marine environment. Effort was initiated to select an alternate material with acceptable characteristics; a limit in maximum hot junction temperature to reduce potential T/E degradation; key dimensions for the converter, and interface control drawing; and effects of increased ambient temperature on converter reliability and performance. Data were recorded and tabulated on three EMC and two PMC converters. End-of-life and beginning-of-life data were tabulated. It is significant that the second generation converters (PMC) demonstrate better performance than the initial converters (EMC) to the extent that contract specifications for end-of-life conditions were exceeded. Additional testing will determine actual electrical and thermal performance characteristics. In addition to the long-term operation testing and data analysis of EMC-2, EMC-3, and PMC-1B, data evaluations and analysis are continuing on the 10-Couple Modules 1, 3, and 5 through 12, converter 23P-2, and Six-Couple Module 23A-3. (J.C.W.)

**17694** (NYO-3883-1) MICROBIAL INHIBITION IN CUTTING OILS EMPLOYING RADIATION: A COST ANALYSIS. PART I. EXPERIMENTAL WORK. PART II. LITERATURE SURVEY AND CONTACT REPORTS. Mixer, R. Y.; Cavallo, J. J.; Hart, W. C. (ARCO Chemical Co., Anaheim, Calif.). July 1968. Contract AT(30-1)-3883. 97p. Dep. CFSTI.

The results of a program designed to determine the economic feasibility of controlling microbial growth in emulsion-type cutting oils by using Microbial Inhibition Systems Employing Radiation (MISER) are described. Microbiological examination of 26 samples of contaminated cutting oil revealed that the microorganisms (bacteria) belonging to the genus Pseudomonas were present in greatest numbers. Bacteria belonging to the genera, Escherichia, Aerobacter, and Paracologactrum were also found to be present in significant numbers. Anaerobic sulfate-reducing bacteria (genus Desulfovibrio) were found to be present in all but two of the cutting oil samples. These latter microorganisms are responsible for the "Monday morning odor" experienced by many industrial users. Yeast and molds were present only in small numbers or not at all. The growth environment presented by the cutting oil emulsion, most specifically pH and substrate, favor the growth of the bacteria. Further, bacteria possess the ability to grow faster (shorter generation time) on the substrates available in the emulsion when compared with yeasts or molds. Consequently, the yeast, molds, and sulfate-reducing bacteria, are considered secondary invaders in the cutting oil system. All of the results obtained from our microbiological survey agree substantially with previous studies presented in the literature. Cost calculations made on the MISER and biocide approaches indicate that the proper use of biocides, complemented by proper control of housekeeping, offers, at this time, the most economical approach. It is our conviction, however, that as pollution control laws stiffen, the biocide approach may lose some of its economic advantage. (auth)

**17695** (ORNL-TM-2223(Pt.4)) SELECTED ABSTRACTS OF NON-U. S. LITERATURE ON PRODUCTION AND INDUSTRIAL USES OF RADIOISOTOPES. From NSA October–December 1968. Gerrard, Martha; Baker, P. S. (Oak Ridge National Lab., Tenn.). Mar. 1969. Contract W-7405-eng-26. 41p. Dep. CFSTI.

Approximately 350 abstracts of non-U.S. publications on production and use of radioisotopes and radiation, selected from the October to December 1968 issues of Nuclear Science Abstracts, are presented. (auth)

**17696** (ORO-665) PROCEEDINGS OF THE ENRICHMENT SERVICES SEMINAR, OAK RIDGE, TENNESSEE, NOVEMBER 7–8, 1968. (Oak Ridge Operations Office (AEC), Tenn.). Mar. 1969. 217p. (CONF-681120). Dep. CFSTI.

Nine papers on US policies and programs in nuclear power, with special emphasis on uranium enrichment capabilities and fuel supply arrangements for enriched reactors abroad, are presented. A separate abstract was prepared for each. (L.C.L.)

*For abstracts of individual papers see: 17697–17700, 17733, 19442, 19443, 19582, and 19583.*

**17697** (ORO-665, pp 73-84) ENRICHING SERVICES AND NUCLEAR POWER. Johnson, Wilfrid E. (Atomic Energy Commission, Washington, D. C.).

The availability, capacity, and cost of uranium enrichment services in the U.S., and policies related to these services are discussed. (L.C.L.)

**17698** (ORO-665, pp 121-45) U. S. GASEOUS DIFFUSION PLANT CAPABILITIES. Sapirie, S. R. (Oak Ridge Operations Office (AEC), Tenn.).

Descriptions are given of the gaseous diffusion separation process for uranium enrichment, of the present operation of US gaseous diffusion plants, and of plans for meeting future requirements for uranium enrichment services. (L.C.L.)

**17699** (ORO-665, pp 147-59) ENRICHMENT SERVICES ECONOMICS. Quinn, George F. (Atomic Energy Commission, Washington, D. C.).

The cost of uranium enrichment services in US gaseous diffusion plants is discussed in terms of factors which influence the overall costs, plant capacities, and predicted charges through FY 1975. (L.C.L.)

**17700** (ORO-665, pp 161-74) SCHEDULES, DELIVERIES, AND CONTAINERS. Keller, Charles A. (Oak Ridge Operations Office (AEC), Tenn.).

The scheduling of feed materials to and products from gaseous diffusion plants and the related questions of weighing, sampling, and analyses are discussed. (L.C.L.)

**17701** (SC-RR-601) ABLATION MATERIAL TESTING. Klett, R. D. (Sandia Labs., Albuquerque, N. Mex.). Dec. 1968. 51p. Dep. CFSTI.

The ablation material test method developed to select the exterior thermal protection for the RFD-2 reentry vehicle is described. Results of the RFD-2 plasma jet test series are presented. (auth)

**17702** (TID-24946) TEST PLAN FOR THE FORMAL MAGNETIC EVALUATION TESTING OF THE MODEL NO. 10 SNAP-27 INTEGRATED POWER UNIT. Dina, M. (General Electric Co., Philadelphia, Pa. Missile and Space Div.). Feb. 1, 1968. Contract AT(30-1)-3535. 103p. (SI-249172). Dep. CFSTI.

Detailed instructions are presented for performing formal magnetic evaluation qualification tests on the Model No. 10 Integrated Power Unit (IPU) of the SNAP-27 IPU System comprising a mated generator assembly and a nuclear fuel capsule assembly. The IPU will be subjected to both natural and induced magnetic mission environments during these tests. These magnetic evaluation tests will be considered as a demonstration of the design capability of the SNAP-27 IPU. Data accumulated from these tests will be incorporated into the SNAP-27 IPU Qualification Test package. (auth)

**17703** (TID-24948) MAGNETIC FIELD ANALYSIS, PART 2: SNAP-27 PROGRAM. Final Report. Wouch, Gerald (General Electric Co., Philadelphia, Pa. Missile and Space Div.). Nov. 30, 1967. Contract AT(30-1)-3535. 84p. Dep. CFSTI.

The stray field analysis of a cold SNAP-27 generator was concluded. The analysis shows that the generator will meet more stringent magnetic field specifications than specified. It is an important power source for magnetically clean spacecraft. An evaluation of the performance of the degaussing loops based on measured data and theoretical computations showed that the loops are functioning in accordance with their purpose. A computer program was written to adjust raw magnetometer data for drift during the test and to fine the coefficients which give the best fit to the data for a selected multipole model. (F.S.)

**17704** ECONOMIC ASPECTS OF A EUROPEAN URANIUM ENRICHMENT INSTALLATION. Bruechner, H.-J. (Allgemeine Elektrizitaetsgesellschaft, Frankfurt am Main). Atomwirt., Atomtech., 14: 72-5(Feb. 1969). (In German).

Some considerations on the economic aspects of a European uranium enrichment installation are presented. These include the size and cost of a gaseous diffusion plant, cost of alternative enrichment methods, and the financing and legal form of a plant. (J.S.R.)

**17705** WHICH SEPARATION METHOD FOR URANIUM ENRICHMENT? Dreissigacker, H.-L.; Schmidt-Keuster, W.-J. Atomwirt., Atomtech., 14: 71-2(Feb. 1969). (In German).

In studies on methods to assure that the European needs for enriched uranium are fulfilled, the gas diffusion method is of primary importance since it has been tested to the fullest. The progress made in the development of two other separation methods, the gas centrifuge and the separation nozzle methods, is however so encouraging that the decision on the construction of large installation should be deferred until the advantages of the various methods are sufficiently compared. (tr-auth)

**17706** $^{252}$Cf: A NEW ISOTOPIC SOURCE FOR NEUTRON RADIOGRAPHY. Reinig, W. C. (E. I. du Pont de Nemours and Co., Aiken, S. C.). Contract AT(07-2)-1. Mater. Eval., 27: 71-2(Mar. 1969).

An evaluation of $^{252}$Cf as a neutron source for radiography is presented. It was found that the source requires no maintenance, transporting the source is practical, and neutron emission is dependable. The cost, production and properties of the $^{252}$Cf source are given and compared to those of a $^{124}$Sb-Be source. (F.S.)

**17707** $^{59}$Fe AS SOLIDS TRACER IN AQUEOUS SUSPENSIONS. Scalf, M. R.; Witherow, J. L.; Priesing, C. P. (Robert S. Kerr Water Research Center, Ada, Okla.). J. Sanit. Eng. Div., Amer. Soc. Civil Eng., 94: 1195-1211(Oct. 1968).

The use of radionuclides for determining the detention of particulate matter in hydraulic systems and to demonstrate simple, fast, and reliable methods of combining these tracers with dye tracers to determine the hydraulic performance of sewage treatment processes was considered. A detection system that could measure radioisotope concentrations in situ was desirable because actual detention times were sometimes needed immediately for subsequent studies. Penetration of $\alpha$ and $\beta$ radiation is slight, and counting equipment requires extensive shielding; therefore, a $\gamma$ emitter was desirable from a detection consideration. The isotope half life must be long enough to allow sufficient time for receipt from the factory, tracer preparation, application, and analysis. It must also be short enough to minimize radioactivity levels from a public health viewpoint and to reduce the background for succeeding tests. Equally important considerations for these experiments were the chemical and physical form of the radioisotope. After consideration of these requirements, $^{59}$Fe was selected as most suitable for these experiments. Iron-59 has 2 hard $\gamma$ rays, one at 1.098 MeV and another at 1.289 MeV. The affinity of $^{59}$Fe for particulate matter was demonstrated. Little of the radioactivity was found in the filtrate of sewage, indicating that essentially all of the tracer material attached permanently to the solids. About 5 $\mu$Ci of $^{59}$Fe/million gal volume of basin studied provided effluent concentrations readily measurable by dip counting with NaI scintillation detectors. The maximum quantity of $^{59}$Fe, averaged over a 24 hr period, which could be released to a sanitary sewer is $6 \times 10^{-5}$ $\mu$Ci/ml. Ten millicuries averaged over a 15 million gal flow is only $1.8 \times 10^{-7}$ $\mu$Ci/ml or about $1/300$ of the maximum allowable concentration. Methods were devised to establish detention times of liquids and solids in an activated sludge sewage treatment plant. Other possible applications include other waste and waste treatment plant processes, silt tracing in rivers and reservoirs, suspension tracing in lagoons, and many sludge handling processes. (BBB)

**17708** PROSPECTS FOR A EUROPEAN ISOTOPE ENRICHMENT PLANT. Michaelis, H. Energ. Nucl. (Milan), 16: No. 3, 44-50(Mar. 1969).

The development of installed nuclear power by 1980 in the European Community and the assurance for reliable uranium supplies are examined for source diversification, improvement of supply conditions from USA, and construction of an isotope separation plant. The arguments of technological and industrial nature of a plant are explained. The technical characteristics of separation processes such as gaseous diffusion and ultracentrifugation are reviewed. The various economic, financial, and judicial aspects of such undertakings are delineated. (auth)

**17709** DETERMINING THICKNESS, DENSITY, AND MOISTURE CONTENT OF WOOD BY RADIOACTIVE ISOTOPES. Onodera, S. Rinsan Shikenjo Kenkyu Hokoku, 47: 1-16(Mar. 1966). (In Japanese).

The glue spreading rate in plywood was determined using beta particles from a $^{90}$Sr-$^{90}$Y source and a G-M radiation detector. Based on test results, this method is applicable for measuring density, thickness, and the glue spreading rate, but in the latter, variance in the veneer should be first determined. Moisture content of wood was determined using fast neutrons from a Ra-Be source and a $BF_3$ counter. Results indicate that the curves of counting rate plotted against moisture content were almost linear, until the thermal energy region where the thermal energies are in equilibrium with the surrounding hydrogen atoms. (F.S.)

**17710** METHOD OF PRODUCING A THULIUM HEAT SOURCE MATERIAL. Fitzgerald, Joseph J.; Mayo, Kenneth E. (to Sanders Nuclear Corp.). U. S. Patent 3,432,386. Mar. 11, 1969. Filed Dec. 2, 1966.

An economic method of producing thulium-171 with a high ratio of thulium-171 to thulium-170 is described. The method comprises irradiating thulium-169 in a high flux neutron reactor to produce a mixture of radioactive isotopes comprising thulium-170 and thulium-171. The mixture is then allowed to decay. Due to the considerably longer half life of thulium-171, the ratio of thulium-171 to thulium-170 in the mixture increases. After a preselected decay time, decay products can be separated leaving a high purity thulium-171 thermal source. (Offic. Gaz.)

**17711** THE SEPARATION OF NEON FROM HIGH-HELIUM-CONTENT NATURAL GASES AND THE ATMOSPHERE FOR ISOTOPIC ANALYSES. Emerson, David E.; Suttle, Elmer T.; Hoffman, C. A. (Helium Research Center, Amarillo, Tex.). J. Mass Spectrom. Ion Phys., 1: 105-10(June 1968).

The isotopic composition of Ne in high He-content natural gases was redetermined in an attempt to relate the findings to the radiogenic theory for the origin of terrestrial He. The apparatus and method are described. The method concentrates Ne directly from high-He-content natural gases or from the atmosphere by utilizing 2 adsorption traps of activated coconut charcoal at 30 and 77°K. The apparatus was used to separate the He and Ne fraction directly from air by surrounding all traps with liquid nitrogen and passing air through the apparatus. Helium and Ne pass through the apparatus and collect in the sample inset system of the mass spectrometer. When sufficient pressure of this mixture is collected, the isotopic composition of Ne is determined by mass spectrometry. Four liters of air furnish sufficient Ne for the isotopic analyses. A table gives a comparison of the present results with previous determinations. The percentage isotopic composition of Ne from atmosphere was $^{20}$Ne 90.61%, $^{21}$Ne 0.264%, and $^{22}$Ne 9.13%. (BBB)

**17712** RAPID SOURCE PREPARATION TECHNIQUE FOR HIGH-RESOLUTION ALPHA-PARTICLE SPECTROSCOPY. Deal, R. A.; Chanda, R. N. (Idaho Nuclear Corp., Idaho Falls). Nucl. Instrum. Methods, 69: 89-92(Mar. 1969).

A rapid method has been developed for the preparation of sources for high-resolution semiconductor alpha-particle spectroscopy. The method involves the extraction of a nuclide into an organic phase. An aliquot of the organic is then transferred to a counting

plate, evaporated to dryness and finally ignited leaving a mass-free plate. Sources prepared in this manner are of a quality equal to other methods currently in use. (auth)

## Materials Testing

*Refer also to abstracts 17645, 17646, 17655, 17706, 17825, and 18259.*

**17713** (BNWL-976) BROADBAND ELECTROMAGNETIC TESTING METHODS. PART V. PULSED EDDY CURRENT METHOD. Libby, H. L. (Battelle-Northwest, Richland, Wash. Pacific Northwest Lab.). Jan. 1969. Contract AT(45-1)-1830. 13p. Dep. CFSTI.

A pulsed eddy current nondestructive test method is described which has the capability of reading multiple parameters of a test specimen. Preliminary results show the separation of signals from irregularities in a short section of ½-in. diameter 304L stainless steel tubing with 0.050-in. wall. An inside circular test coil about 7/16-in. diameter was used. Signals from two parameters, probe wobble and the presence of a small piece of ferrous material on the outside of the tubing, were discriminated against. Signals caused by two other parameters, a fabricated notch on the inside wall and a fabricated notch on the outside wall, were separated and read on separate output channels. (auth)

**17714** (EURAEC-2071) PROGRESS REPORT [ON MATERIALS TESTING]. (Ghent Rijksuniversiteit (Belgium)). Sept. 30, 1968. Contract 081-67-1-TEEC(RD). 13p. Dep. CFSTI.

Work Performed under United States-Euratom Joint Research and Development Program.

Electroslab welds were evaluated using Robertson tests on Super-Elso steel plates. The test plate which was 85 mm thick was electroslag welded on either side to a mild steel plate 75 mm thick. Electroslag welding was found to give rise to a brittle layer in the base metal near the fusion line. It is believed that electroslag welds produced under good technological conditions suffice as a joint between a Robertson specimen and the relaxation plates. (F.S.)

**17715** (RD/B/N-1217) ECONOMICAL COMPUTER TECHNIQUES FOR SOLID FINITE ELEMENTS. Hellen, T. K. (Central Electricity Generating Board, Berkeley (England). Berkeley Nuclear Labs.). Dec. 1968. 13p. Dep. CFSTI.

A method of numerical integration for stress analysis calculations is described which economizes on the time and core storage requirements for more complex elements. (UK)

**17716** NON-DESTRUCTIVE CONTACTLESS TESTING OF NON-MAGNETIC METALLIC REACTOR COMPONENTS. Vozenilek, Frantisek; Kovar, Pavel (Inst. of Nuclear Research, Rez, Czech.). Nucl. Eng. Design, 8: 380-90(Sept.-Oct. 1968).

The Czechoslovak WWR-S reactor will be operated at an increased power, and, therefore, special attention must be given to the detection of defects in various reactor components. In this connection experimental contactless nondestructive measurements of some reactor components were carried out. A survey is presented of various nondestructive measuring methods used in U. S. nuclear establishments. The use of a new method is discussed, and experimental results are given on measurments on: aluminum tubes used as fuel element cladding; fuel element mock-ups; original fuel elements before operation; aluminum irradiation ampules; and some stainless steel knee tubes used in the reactor. (auth)

**17717** APPLICATION OF GAMMA RADIOGRAPHY TO POWER CABLE. Shimizu, Naoyuki; Sugimori, Mikihiko (Furukawa Electric Co., Ltd., Japan). Furukawa Denko Jiho, No. 45, 58-64(Nov. 1968). (In Japanese).

The application of gamma radiography to nondestructive testing of power cable was studied. It was found to be an effective means of improving the quality and reliability of the power cable and to aid in cable designing. (NSA of Japan)

**17718** PROCEEDINGS: 1968 SYMPOSIUM ON THE NDT OF WELDS AND MATERIALS JOINING, LOS ANGELES, CALIF., MARCH 11-13, 1968. Evanston, Ill., The American Society for Nondestructive Testing, Inc., 1968. 735p. $20.50. (CONF-680304).

Twenty-seven papers were presented at the conference. A separate abstract was prepared for each of 5 papers. The remaining 22 papers contain information on various methods and techniques used in nondestructive testing of welds not within the scope of NSA. (R.C.K.)

*For abstracts of individual papers see: 17719-17723.*

**17719** RESEARCH AND DEVELOPMENT IN COLOR RADIOGRAPHY. Beyer, Norman S.; Staroba, Jerry F. (Argonne National Lab., Ill.). pp 557-72 of Proceedings: 1968 Symposium on the NDT of Welds and Materials Joining. Evanston, Ill., The American Society for Nondestructive Testing, Inc., 1968.

From 3rd Annual Symposium on Nondestructive Testing of Welds and Materials Joining, Los Angeles, Calif. See CONF-680304.

The most likely application of color radiography in inspection problems lies in its high latitude characteristics. Objects which contain a large range of opacity to radiation will be more completely inspected with color radiography. Parameters of hue and saturation will aid in obtaining better resolution. When continuity of image is important for proper interpretation and a sensitivity of 2% or higher can be tolerated, color radiography will be helpful. Ektachrome or Ektacolor film were investigated. Ektacolor Professional Paper shows most promise for use in color radiography. (F.S.)

**17720** IN-SITU MEASUREMENT OF OXYGEN IN WELDS BY NONDESTRUCTIVE NEUTRON ACTIVATION ANALYSIS. Guinn, Vincent P. (Gulf General Atomic, Inc., San Diego, Calif.). 547-56 of Proceedings: 1968 Symposium on the NDT of Welds and Materials Joining. Evanston, Ill., The American Society for Nondestructive Testing, Inc., 1968.

From 3rd Annual Symposium on Nondestructive Testing of Welds and Materials Joining, Los Angeles, Calif. See CONF-680304.

The quantitative determination of oxygen in discrete samples of metals or other materials by rapid, nondestructive, neutron activation analysis is now a widely used technique. With sufficiently large samples (~30 grams), and the best of available equipment, oxygen concentrations can be accurately measured down to levels as low as 1 ppM. It is shown that, with somewhat more modest equipment, the same technique can be applied to the in-situ determination of oxygen in welds, down to levels of about 50 ppM. An intermittent, rather than continuous, procedure is preferred, for a number of reasons. A section of weld one to three inches in length is exposed for 5 to 15 seconds (as required) to the 14 MeV neutron flux just in front of the tritium target of a $10^{10}$-$10^{11}$ n/sec output neutron generator (small Cockcroft-Walton deuteron accelerator). The generator is then displaced about 5 feet, bringing the activated section adjacent to a large NaI(Tl) scintillation detector. The displacement time needed is about 5 seconds. The 6.13 MeV gamma rays of the 7.14-second $^{16}N$, produced in the oxygen by the $^{16}O(n,p)^{16}N$ reaction, are then counted for 5 to 15 seconds (as required), the system displaced again to bring the next section of the weld in front of the generator target and the procedure repeated until the entire length of the weld has been surveyed. (auth)

**17721** ASME CODE ULTRASONIC EXAMINATION OF WELDS: AN ANALYSIS. Roehrs, Robert J. (Quality Assurance Nooter Corp., St. Louis). pp 288-371 of Proceedings: 1968 Symposium on the NDT of Welds and Materials Joining. Evanston, Ill., The American Society for Nondestructive Testing, Inc., 1968.

From 3rd Annual Symposium on Nondestructive Testing of Welds and Materials Joining, Los Angeles, Calif. See CONF-680304.

A workable ultrasonic weld examination code prepared by the ASME Sub Group on Ultrasonics is described. Procedures for the detection, location, and evaluation of defects by the pulse-echo ultrasonic method are discussed. The continual advancement of the state of the art is largely dependent on the wide distribution of up-to-the-minute technical information; therefore, this analysis is being presented almost concurrently with the issuance of the code documents. It includes a technical discussion and explanation of the advantages and disadvantages of using various calibration reflectors. In addition, other areas discussed include the proposed calibration procedure, the reasoning behind the calibration transfer technique, as well as some of the thinking that prompted the ASME Sub Group on Ultrasonics to add many other concepts. (auth)

**17722** ACOUSTIC EMISSION: A NEW NONDESTRUCTIVE TESTING TOOL. Dunegan, H.; Harris, D. (Univ. of California, Livermore). pp 203-38 of Proceedings: 1968 Symposium on the NDT of Welds and Materials Joining. Evanston, Ill., The American Society for Nondestructive Testing, Inc., 1968. (UCRL-70750).

From 3rd Annual Symposium on Nondestructive Testing of Welds and Materials Joining, Los Angeles, Calif. See CONF-680304.

A new approach to nondestructive testing is proposed which is centered around the concept of utilizing transducer action of a flaw in a stress field resulting in localized plastic deformation occurring in the vicinity of the flaw which in turn gives up energy in different ways. Thermal emission, exo-electron emission and acoustic emission are the three primary forms that this energy takes upon release. The first two of these are mentioned only briefly as challenging new areas of research, while the subject of acoustic emission is more completely discussed. Acoustic emission from unflawed tensile specimens can be treated from

a dislocation dynamics approach. A good correlation between the acoustic emission and a proposed theoretical model for mobile dislocation density as a function of plastic strain is shown for aluminum. A theoretical model for the plastic volume around a sharp crack in an elastic stress field previously developed, predicted that the summation of acoustic emission should vary as the fourth power of the stress intensity factor at the crack tip. Experimental data from 7075-T6 aluminum agrees with this model. Acoustic emission data from flawed specimens, interpreted from a fracture mechanics viewpoint finds direct application for nondestructive quality assurance tests on engineering structures. (auth)

**17723** NONDESTRUCTIVE TESTING OF SPACE VEHICLE LIQUID PROPELLANT ROCKET ENGINES. Hagemaier, D. (Rocketdyne, Canoga Park, Calif.). pp 107-37 of Proceedings: 1968 Symposium on the NDT of Welds and Materials Joining. Evanston, Ill., The American Society for Nondestructive Testing, Inc., 1968.

From 3rd Annual Symposium on Nondestructive Testing of Welds and Materials Joining, Los Angeles, Calif. See CONF-680304.

Nondestructive test methods employed to evaluate materials and processes used in the manufacture of large liquid propellant rocket engines are described. A brief description of liquid propellant rocket engine reliability is presented. The relationship of standards and specifications to nondestructive testing is discussed and various test methods are described along with a discussion of their applications and limitations. The sequence of events leading up to the use of nondestructive testing in production inspection is presented. Finally, the organization of labor directly related to nondestructive testing is given. (auth)

## Radioactive Material Handling

*Refer also to abstracts 17700, 17702, 17761, and 19566.*

**17724** (BMwF-FBK-68-41) ROCK-MECHANICAL INVESTIGATIONS OF SALT ROCKS FROM THE ASSE II MINE NEAR WOLFENBUETTEL WITH SPECIAL REFERENCE TO THE STABILITY AND CONVERGENCE OF THE UNDERGROUND WORKINGS AND TO THE REAL LOADING OF PILLARS, SAFETY ROOFS, AND SHAFTS. Borchert, H.; Dreyer, W. (Gesellschaft fuer Strahlenforschung m.b.H., Clausthal-Zellerfeld (West Germany). Institut fuer Tierflagerung. Technische Hochschule, Clausthal-Zellerfeld (West Germany). Mineralogisch-Petrographisches Institut). Sept. 1968. 130p. (In German). Dep.

Studies concerning the suitability of the Asse II salt mine for disposal of radioactive wastes and laboratory investigations in the field of rock mechanics of Asse-salt rocks are described. Based on the strength parameters of the "Liniensalz" and the results of model studies, the stability of pillars and safety roofs is determined. The most important methods to indicate the in situ development and the results of rock pressure around mining openings are discussed. By applying the experiences resulting from these investigation methods to the special strata and working conditions in the Asse II mine, an evaluation of the stability of its underground working area is given. (auth)

**17725** (BNWL-968) WASTE SOLIDIFICATION PROGRAM. VOLUME II. DESIGN FEATURES OF THE WASTE SOLIDIFICATION ENGINEERING PROTOTYPES. Schneider, K. J.; Kelly, V. P. (Battelle-Northwest, Richland, Wash. Pacific Northwest Lab.). Feb. 1969. Contract AT(45-1)-1830. 221p. Dep. CFSTI.

General design criteria and descriptions of the Waste Solidification Engineering Prototypes equipment are discussed. The WSEP is a developmental facility for solidifying highly radioactive liquid wastes from reprocessing of power reactor fuels by the pot, spray, and phosphate glass processes. Design criteria are based upon providing a developmental facility with a high degree of flexibility and integrity for demonstrations of various waste solidification processes and equipment with fully radioactive materials. Special features of the equipment for process and mechanical functions to be performed during the demonstrations are presented. Process functions include overall flowsheet requirements, process control features, process effluent treatment and control, and special features of process equipment. Mechanical functions include remote handling and transfer of material and equipment, and storage and testing of containers full of solidified waste. Equipment performance during nonradioactive shakedown tests, and the process safety review are summarized. Equipment performance has been good, and the first radioactive run was made in the WSEP in November 1966. (auth)

**17726** (CEA-CONF-1196) VITRIFICATION OF THE SOLID FLUORIDE RESIDUE ARISING FROM THE REACTION OF FLUORINE ON IRRADIATED FUEL. Bonniaud, R.; Labe, P. (Commissariat a l'Energie Atomique, Fontenay-aux-Roses (France). Centre d'Etudes Nucleaires). [nd]. 19p. (In French). (CONF-681040-8). Dep.

From Symposium on Nonaqueous Reprocessing, Mol, Belgium.

The vitrification of residues from the fluoride attack on fuel elements was studied. The characteristics of the fluoride wastes from the reaction vessel and from the static filter are outlined. Tests were made on the complete coating of the wastes in a glassy solid block which would be stackable. The technique used was described, and the effect of the fluoride concentration on the vitrification process was determined. The physical characteristics of the glass with respect to thermal conductivity and mechanical resistance were satisfactory. The tests indicated that the volatile fluorides must be stabilized by their transformation into alkaline earth fluorides. The silicophosphorated compositions were satisfactory for the coating. (J.S.R.)

**17727** (CEA-R-3632) COATING OF EVAPORATION CONCENTRATES WITH BITUMEN. Progress Report No. 1. Rodier, Jean; Lefillatre, Guy; Rodi, Lucienne; Cudel, Yvonne (Commissariat a l'Energie Atomique, Chusclan (France). Centre de Production de Plutonium de Marcoule). Nov. 1968. 114p. (In French). Dep.

Laboratory tests were carried out on the coating by bitumen of evaporation concentrates having a free nitric acidity of 1 N or 2.5 N, and a high mineralization (400 g/l). In order to neutralize the free acidity and to trap the radioelements, these concentrates were subjected to various treatments before coating to decrease the solubility. As a result of these treatments, sludges were obtained which could be coated directly with the bitumen. By measuring the radioactive diffusion factors of the bitumen coated products immersed both in ordinary and seawater, it was possible to compare the efficiency of the processes developed and of the various types of bitumen used. On the whole the radioactive diffusion tests were satisfactory and the process using successive coprecipitations (hydroxides, nickel ferrocyanide, barium sulphate) was chosen. From the bitumens tried, an asphalt, Mexphalt 40/50, was selected for low and medium activity concentrates as it ensures good isolation of the radioelements; an air-blown asphalt, Mexphalte R 90/40, was chosen for concentrates of high activity because of its higher resistance to irradiation. A simple coating technology was evolved and pilot experiments will begin. Although a method for coating evaporation concentrates with bitumen has been defined, it will be necessary to devise a specific decontamination process each time that a new type of concentrate is encountered (composition, nature of the salts, radio-element distribution). (auth)

**17728** (CEA-R-3661) DECONTAMINATION USING FOAM-SUPPORTED CHEMICAL PRODUCTS. Boutot, Pierre; Schipfer, Pierre (Commissariat a l'Energie Atomique, Chusclan (France). Centre de Production de Plutonium de Marcoule). Jan. 1969. 19p. (In French). Dep.

Decontamination tests using chemical products supported on a foam were carried out on large cross-section tubing, with a view to reducing both the amounts of products used and the volumes of radioactive waste produced. The method is based on the use of conventional chemical products, in normal concentration and temperature conditions but employed in the form of a foam in a cyclic circulation. In comparison to results obtained with a decontamination by soaking, this process has proved to be as efficient when used with nitric and citric acids, but much less so in the case of caustic soda. (auth)

**17729** (CEA-R-3664) DECONTAMINATION OF LATEX GLOVES. Boutot, Pierre; Schipfer, Pierre; Blachere, Albert (Commissariat a l'Energie Atomique, Chusclan (France). Centre de Production de Plutonium de Marcoule). Jan. 1969. 15p. (In French). Dep.

Initially the latex gloves used in controlled zones were processed after use as radioactive waste. In view of the continually increasing number used, the possibility of decontaminating the gloves and using them again after control was considered. The recovery installations initially were designed crudely and operated irregularly. They have been progressively improved as a result of the experience acquired. Today they are more nearly an industrial concern, equipped with automatic machinery. It has been possible with this set-up to recover 247,000 pairs of gloves, representing nearly 70% of the number treated. (auth)

**17730** (KY-552) DEMONSTRATION FUEL ELEMENT SHIPPING CASK FROM LAMINATED URANIUM METAL. PART III. TESTS AND DEMONSTRATIONS. Clifford, C. B. (Paducah Gaseous Diffusion Plant, Ky.). Mar. 12, 1969. 122p. Dep. CFSTI.

A demonstration fuel element shipping cask that uses laminated

uranium metal as the shielding material was designed, fabricated, tested, and evaluated. Destructive and nondestructive test programs designed to demonstrate the capability of the cask for successfully meeting the applicable transit design criteria and passing the hypothetical accident series described therein are described. The test facilities and equipment utilized, the scope of general test work prior to the destructive and nondestructive test programs, and details of the destructive and nondestructive test programs are reported. (auth)

**17731** (ORNL–3358(Rev.)) EVALUATION OF ULTIMATE DISPOSAL METHODS FOR LIQUID AND SOLID RADIOACTIVE WASTES. VI. DISPOSAL OF SOLID WASTES IN SALT FORMATIONS. Bradshaw, R. L.; Perona, J. J.; Blomeke, J. O.; Boegly, W. J. Jr. (Oak Ridge National Lab., Tenn.). Mar. 1969. Contract W-7405-eng-26. 90p. Dep. CFSTI.

The cost of disposing of high-level solidified wastes in bedded salt formations was studied. A conceptual design of a salt mine is developed for disposal of wastes from the recovery of spent uranium and thorium reactor fuels from a 15,000-MW(e) nuclear power economy. The waste products are contained in "pots" 6, 12, and 24 in. in diameter by 10 ft long and are buried in vertical holes in the floor of a mine 1 sq mile in area and located 1000 ft below the surface. The operating life of this mine and the costs of the mining and disposal operations are calculated, using rather conservative mine stability criteria, for various waste ages, pot sizes, and waste compositions. The life of the mine was found to range from about 12½ years for wastes aged 1 year at the time of burial to about 70 years for wastes aged 30 years at burial. The initial capital outlay required to start waste disposal operations ranged from about $8.4 million to $10.7 million. The annual capital and operating costs for the facility are dependent on waste combinations and pot sizes and vary from about $2.6 million for a 1-year-old waste to about $1.2 million for 30-year-old wastes. Using present worth considerations, the money to be set aside annually at the time of waste generation ranges from about $2.5 million for a 1-year-old waste to about $400,000 for a waste 30 years old at the time of disposal. In terms of the cost per kilowatt-hour of electricity generated, these amounts correspond to about $19 \times 10^{-3}$ mill and $3 \times 10^{-3}$ mill, respectively. (auth)

**17732** (ORNL–4361) MAXIMUM TEMPERATURE RISE IN CYLINDERS CONTAINING INTERMEDIATE-LEVEL AND HIGH-LEVEL SOLIDIFIED RADIOACTIVE WASTES. Davis, W. Jr.; Fitzgerald, C. L.; Soard, H. F. (Oak Ridge National Lab., Tenn.). Mar. 1969. Contract W-7405-eng-26. 34p. Dep. CFSTI.

Calculations were made of the maximum temperature rise in cylinders containing solidified intermediate-level and high-level radioactive wastes. The storage form for intermediate-level waste (ILW) was asphalt. Maximum centerline temperatures were calculated as a function of power density, cylinder diameter, and cylinder length/diameter ratio for a thermal conductivity of 0.153 Btu $ft^{-1}$ $hr^{-1}$ $°F^{-1}$ ($6.32 \times 10^{-4}$ cal $cm^{-1}$ $sec^{-1}$ $°C^{-1}$). The power density was varied from 0.5 to 8 Btu $hr^{-1}$ $ft^{-3}$, and the cylinder diameter was varied from 1 to 14 ft; length/diameter ratios of 1 and 2 were used. The storage forms considered for the high-level radioactive wastes were calcine, phosphate glasses, and calcine dispersed in a glass matrix. These materials have a wide range of thermal conductivities. Maximum temperature rises were calculated as a function of power density and cylinder diameter for long cylinders (length/diameter ≥ 5) at a surface temperature of 122°F (50°C); this corresponds to storage under water, at power densities of 2000 to 80,000 Btu $hr^{-1}$ $ft^{-3}$, and cylinder diameters of 6 to 48 in. These calculations show that 55-gal drums (~2 ft diam by 4 ft high) could be used to store ILW-asphalt products having power densities as high as 8 Btu $hr^{-1}$ $ft^{-3}$ without exceeding a centerline temperature of 122°F for a surface temperature of 77°F. A container with a diameter up to 10 ft (length/diameter ≤ 2) would be suitable for material having a power density as low as 2 Btu $hr^{-1}$ $ft^{-3}$. If future high-level wastes, such as those from liquid-metal-cooled fast breeder reactor (LMFBR) or high-temperature gas-cooled reactor (HTGR) fuels, are to be solidified after out-of-reactor times as short as 1 year or less with a requirement that the centerpoint temperature not exceed 900°C, then they must be either diluted with inert solids or stored as materials having significantly higher thermal conductivities than those of calcines. (auth)

**17733** (ORO–665, pp 85-119) REVIEW OF ENRICHED URANIUM FUEL CYCLE. Hibbs, Roger F. (Union Carbide Corp., Oak Ridge, Tenn. Nuclear Div.).

Details of the enriched uranium fuel cycle which will accompany the operation of a 1000 MW(e) light water reactor in 1980 are discussed and include: uranium mining and milling; conversion to $UF_6$; enrichment; $UO_2$ fuel assembly fabrication; fuel management and irradiation; spent fuel processing, shipping, and storage; and waste management. The predicted cost of each operation is given. (L.C.L.)

**17734** SHIPPING CONTAINER FOR UNIRRADIATED FUEL ELEMENTS. Gruener, W. (Siemens-Schuckertwerke AG, Erlangen, Ger.). Nucl. Eng. Design, 8: 321-6(Sept.-Oct. 1968).

The problems met during the design of a shipping container for unirradiated nuclear fuel elements for a pressurized water reactor are described. These include: classification of shipment; package design requirements; nuclear safety; design of fuel element fixture; design of suspension system between cradle and shell; and design of container shell. (auth)

**17735** PROJECT SALT VAULT: DESIGN OF EQUIPMENT. Schaffer, W. F. Jr.; Boegly, W. J. Jr.; Bradshaw, R. L.; Parker, F. L. (Oak Ridge National Lab., Tenn.). Nucl. Eng. Design, 8: 327-36(Sept.-Oct. 1968).

Handling, transfer and storage techniques applicable to high-level solid waste disposal operations have been successfully demonstrated with short-cooled ETR fuel assemblies. The design of equipment for the encapsulation of the fuel assemblies, cross-country shipment, transfer from the surface to the mine level, movement within the mine, and transfer into storage are described. The operations are unique in that high-level radioactive materials are transferred from a shipping cask on the surface to the mine level 1000 ft below without the use of hot cells. (auth)

**17736** DISPOSAL OF HIGH ACTIVITY POWER REACTOR WASTES IN SALT MINES: MINE RENOVATIONS REQUIRED FOR PROJECT SALT VAULT. Boegly, W. J. Jr.; Empson, F. M.; McClain, W. C.; Parker, F. L. (Oak Ridge National Lab., Tenn.). Nucl. Eng. Design, 8: 360-6(Sept.-Oct. 1968).

Project Salt Vault is a field-scale demonstration of the disposal of high-level radioactive wastes in a salt mine. Preparations required for the experiment included construction of a new headframe for the main mine shaft, renovation of the existing surface and underground facilities mining of about 19,000 tons of salt to prepare the experimental area, and drilling of a 19.1-in. id waste-charging shaft from the surface to the mine level, 1000 ft below. (auth)

**17737** REMOTE-CONTROL MANIPULATOR. Le Guennec, R. (to Commissariat a l'Energie Atomique). Canadian Patent 801,639. Dec. 17, 1968. Priority date Dec. 28, 1964, France.

A master-slave manipulator consisting of a tube adapted to traverse either the wall or the roof of a totally enclosed hot cell is described. The master assembly on the outside and slave assembly inside the cell are formed of articulated members having an upper arm and a forearm to enable the device to reach around behind an object. The master control handle and the corresponding slave grab have operating means capable of producing rotational movement of the upper arm and forearm independently of any other movements. The movements used for manipulation are transmitted by cables, belts, chains and pulleys but without the use of a gear system which could result in "play" or a dead point when immediate response is desired. Several simultaneous degrees of freedom are thus attained. (F.S.A.)

**17738** SHIPPING CONTAINER (Engineering Materials). (Richland Operations Office (AEC), Wash.). (CAPE–1840). 3 drawings.

The construction details of Class II, L-10 shipping containers used in shipping plutonium nitrate solutions are described. The $Pu(NO_3)_4$ is contained in a 10 liter high density polyethylene bottle with a vented cap. The bottle is contained in a pressure chamber fabricated of Sch 80 pipe hydrostatically tested to 900 psig. The insulation is vermiculite. (For details see TID-4100 Suppl 51.) (F.S.)

**17739** DRY HOLE CHARGER SHIPPING CASK (Engineering Materials). Oak Ridge National Lab., Tenn.). (CAPE–1845). 12 drawings.

The Dry Hole Charger Shipping Cask used in shipping samples and waste from ORNL to various domestic locations is described. The maximum thermal load generated by the contents is 100 W. The cask is fabricated from stainless steel. The biological shield is lead. The cask is loaded and unloaded through the unsealed top plug or the bottom sliding doors. The shipping skid and the fire shield, which is fabricated of stainless steel sheet, are also described. (For details see TID-4100, Suppl. 51). (See also NSA 23: 7717). (F.S.)

**17740** CONTAINERS FOR TRANSPORTING RADIOACTIVE AND/OR FISSILE MATERIALS. Nash, Geoffrey James Chetewoode; Harding, Keith (to United Kingdom Atomic Energy Authority). U. S. Patent 3,432,666. Mar. 11, 1969. Priority date Mar. 13, 1965, Great Britain.

A transport container for radioactive material comprising a casing which includes a radiation attenuating substance dispersed in a matrix is described. A moderator material affords fire protection for the container by employing a hydrated salt of boron which absorbs heat as its water of crystallization is driven off through vent holes in a layer surrounding the casing. (Offic. Gaz.)

# INSTRUMENTATION

## Radiation Detection Instruments

*Refer also to abstract 19319.*

### General Detectors and Monitors

*Refer also to abstracts 17448, 17459, 17541, 17545, 18019, 18054, 18459, 18611, 19024, and 19105.*

**17741** (AAEC/TM-484) CORRECTION OF AUTORADIOGRAPHIC IMAGES FOR BROADENING. Bradhurst, D. H.; Walker, D. G. (Australian Atomic Energy Commission Research Establishment, Lucas Heights). Nov. 1968. 7p. Dep.

The measurement of diffusion profiles by autoradiography requires that the observed images be corrected for broadening. Satisfactory corrections can be obtained using matrix methods. (auth)

**17742** (BLG-425) PROCEEDINGS OF THE MEETING ON THE APPLICATIONS OF Ge(Li) DETECTORS IN SCIENCE, TECHNOLOGY, MEDICINE, AND INDUSTRY, BRUSSELS, OCTOBER 20, 1967. (Centre d'Etude de l'Energie Nucleaire, Brussels (Belgium)). 94p. (CONF-671078). Dep.

Separate abstracts were prepared for the five papers presented. (W.H.K.)

*For abstracts of individual papers see: 17743, 17744, and 17783–17785.*

**17743** (BLG-425, Paper 2) PRODUCTION AND FUNDAMENTAL PROPERTIES OF GERMANIUM SINGLE CRYSTALS WITH RESPECT TO THEIR APPLICATION IN $\gamma$-RAY DETECTORS. De Laet, L. 16p.

Germanium refining and single crystal pulling techniques are briefly discussed. Fundamental properties of germanium single crystals considered include resistivity and type, Hall effect, minority carrier lifetime, physical perfection, oxygen determination, and migration and precipitation of lithium. (W.H.K.)

**17744** (BLG-425, Paper 3) GERMANIUM DETECTORS IN CHEMICAL ANALYSIS. Adams, F. (Ghent Rijksuniversiteit (Belgium). Instituut voor Kernwetenschappen). 15p.

The uses of lithium-drifted germanium detectors in activation analysis and x-ray fluorescence analysis are summarized. (W.H.K.)

**17745** (CEA-R-3697) THERMAL NEUTRON FLUX MEASUREMENTS USING NEUTRON-ELECTRON CONVERTERS. Le Meur, Roger; Lecomte, Pierre (Commissariat a l'Energie Atomique, Saclay (France). Centre d'Etudes Nucleaires). Dec. 1968. 45p. (In French). Dep.

The operation of neutron-electron converters designed for measuring thermal neutron fluxes is examined. The principle is to produce short lived isotopes emitting beta particles, by activation, and to measure their activity not by extracting them from the reactor, but directly in the reactor using the emitted electrons to deflect the needle of a galvanometer placed outside the flux. After a theoretical study, the results of the measurements using silver and vanadium converters are presented. Particular attention is paid to a new type of converter characterized by a layer structure. The converters are very useful for obtaining flux distributions with more than $10^7$ neutrons $cm^{-2}$ $sec^{-1}$. They work satisfactorily in pressurized carbon dioxide at 400°C. Some problems still have to be cleared up however concerning interfering currents in the detectors and the behavior of the dielectrics under irradiation. (auth)

**17746** (HMI-B-79) NUCLEAR CHEMISTRY DIGEST. PART II. NUCLEAR RADIATION INSTRUMENTATION. Friese, T.; Klessmann, H. (Hahn-Meitner-Institut fuer Kernforschung, Berlin (West Germany)). Jan. 1969. 109p. (In German). Dep.

Since 1957 nuclear chemistry courses have been presented regularly for advanced students at the Berlin universities and for graduates in chemistry, physics, biology, medicine, etc. The material presented in the courses was compiled and published in eight parts. Material on nuclear radiation instrumentation is presented. Detectors, electronic components of radiation detection devices, and pulse analyzers are considered. The electronic characteristics affecting the instrumentation are defined. (J.S.R.)

**17747** (ISS-68/28) MEASUREMENT OF ABSOLUTE ACTIVITY OF $^{60}$Co SOLUTIONS BY MEANS OF $4\pi$ $\beta-\gamma$ COINCIDENCE METHOD. Grisanti, A.; Tori, P. (Istituto Superiore di Sanita, Rome (Italy). Laboratori di Fisica). Sept. 16, 1968. 26p. (In Italian). Dep.

The apparatus and technique for high-precision $4\pi\beta-\gamma$ coincidence counting are described. The method of preparation of thin solid sources of $^{60}$Co for absolute activity measurement is discussed. Results of testing on the accuracy and reproducibility of the counting apparatus are presented. (auth)

**17748** (JAERI-5017, pp 77-82) MAINTENANCE OF MONITORS AND COUNTING INSTRUMENTS. (Japan Atomic Energy Research Inst., Tokyo). (In Japanese).

All monitors and survey-meters in the JAERI were checked and calibrated every three or four months, and many troubles were detected due to the superannuation of instruments. To reduce the troubles, new instruments were developed and a project for the renewal of monitors was started. In the meantime, high operating rates of monitors (higher than 95%) were attained by prompt repair. The number of $\alpha$-samples measured in the counting room in 1967 increased to 2.5 times than in 1966. This tendency for the increase will continue in the future. Measurements of neutron dose equivalent rates around a cyclotron were carried out in Feb., 1968. Some useful data, on the monitoring of high-energy neutrons, were obtained. For the future installation of high-energy accelerators, the study of dosimetry on high-energy neutrons and x-rays must be emphasized. (auth)

**17749** (JAERI-5017, pp 107-30) INSTRUMENTATION. (Japan Atomic Energy Research Inst., Tokyo). (In Japanese).

A number of monitoring instruments and measuring methods were developed in 1967. Furthermore, some detailed characteristics of the instruments for monitoring were obtained. (1) Self-absorption factors for $\alpha$, $\beta$-particles in smear and dust samples were determined. (2) Some characteristics of detectors, such as contamination monitors, a gas-flow counter and a large-size scintillator, were obtained. Applicabilities of TLD and scintillator-films to radiation monitoring were studied. (3) A new type rate-meter with integrated circuits was developed with the intention of standardizing circuits used in monitors. Other instruments, such as a clothmonitor, a proportional counter for monitoring of Pu in lung and a monitoring-post system in Oarai Institute were developed successfully. (4) A new type hand-foot-clothes monitor manufactured to improve the sensitivity for $\beta$ emitters of low energies was examined for the minimum detectable amounts of skin surface contamination. (5) Calibration and performance test of a tritium-in-air monitor were carried out. (6) Alarming devices for criticality accidents were reviewed and a device consisting of two ionization chambers covered with indium of different thickness and one bare ionization chamber was planned. Fundamental experiment relating to this alarming device will be undertaken in the near future. (auth)

**17750** (LA-4052) THE PHOTON ENERGY RESPONSE OF SEVERAL COMMERCIAL IONIZATION CHAMBERS, GEIGER COUNTERS, SCINTILLATORS, AND THERMOLUMINESCENT DETECTORS. Krohn, Bruce J.; Chambers, William B.; Storm, Ellery (Los Alamos Scientific Lab., N. Mex.). Oct. 1968. Contract W-7405-eng-36. 28p. Dep. CFSTI.

The photon energy response of 15 commercial ionization chambers, six Geiger counters, and two thermoluminescent dosimeters was measured from 8 to 1250 keV. Only those commercial instruments in routine or special use at Los Alamos were tested. (auth)

**17751** (PG-Report-864) ABSOLUTE COUNTING OF FISSION PRODUCT ACTIVITIES USING $4\pi\beta$ AND $4\pi\beta-\gamma$ COINCIDENCE TECHNIQUES. Cunningham, R. A. (United Kingdom Atomic Energy Authority, Sellafield (England). Production Group). 1968. 42). Dep. CFSTI. UK 7s. 0d.

The design and performance of $4\pi\beta$ and $4\pi\beta-\gamma$ coincidence gas-flow proportional counters are described. The absolute disintegration rates of various isotopes were determined, and the methods used are described together with the precisions obtained. The accuracy of most of the methods was checked by redetermining the disintegration rates of absolute standard solutions. Comparison of the results showed good agreement. (UK)

**17752** GERMANIUM RADIATION DETECTORS COMPENSATED BY IRRADIATION DEFECTS. Kimerling, L. C.; Golovin, L. B.; Gatos, Harry C. (Massachusetts Inst. of Tech., Cambridge). Proc. IEEE (Inst. Elec. Electron. Eng.), 57: 208-9 (Feb. 1969).

A method is described for the preparation of room-temperature-stable germanium radiation detectors. Some preliminary observations are presented concerning the role of materials and fabrication parameters in detector performance. (auth)

**17753** COMPUTER CONDITIONED IMAGES OF SCINTILLATION SCANS. Meckstroth, George R. (Tulane Univ., New Orleans). pp 21-8 of Symposium on Computers and Scanning. Hidalgo, John U. (ed.). New York, Society of Nuclear Medicine, 1967.

See CONF-651210.

A system employing a flying spot scanner, analog-to-digital converter and IBM 1410 computer is used to improve, for visual interpretation, scintillation scan pictures. Improved interpretability is obtained by elimination of non-data rows and the use of an elliptical technique. The computer conditioned image may be used as an aid in the detection of areas of increased or decreased activity, not readily apparent on the original scan, even if the scan is not of perfect quality. Isoresponse pattern may be represented by appropriate choice of gray levels. (auth)

**17754** DIGITAL COMPUTER ANALYSIS AND DISPLAY OF THE RADIONUCLIDE SCAN. Brown, Donald W. (Colorado Univ., Denver). pp 29-40 of Symposium on Computers and Scanning. Hidalgo, John U. (ed.). New York, Society of Nuclear Medicine, 1967.

See CONF-651210.

In order to obtain greater objectivity in the interpretation of radionuclide scans through the application of statistical testing, a new method of analysis and display of the data available from the scanner, using digital computer techniques, is under development. One hundred routine clinical scans, studied in this way, were correlated with simultaneous photoscans and the patient's clinical findings. The results of the computed scans were at least as good as those obtained with photoscanning. A great advantage of computer processing of scans is the ability to quantitate the results of scanning, providing some information was not previously available. These developments are in their infancy and it is felt that their future is bright. (auth)

**17755** GRAPHIC QUENCHING CORRECTIONS FOR LIQUID SCINTILLATION COUNTERS. Winkler, K. (Deutsche Akademie der Wissenschaften, Berlin. Zentralinstitut fuer Physikalische Chemie, Radionuklidlabor, Berlin). J. Radioanal. Chem., 2: 133-40(Jan. 1969). (In German).

A nomogram for quench corrections of $^{14}C$ counters was devised. The guide code is given. Two examples are given of the use of the nomogram. (J.S.R.)

**17756** CONSTRUCTION AND PERFORMANCE OF HIGH RESOLUTION SILICON SURFACE BARRIER DETECTORS. Tomlinson, F. K. (Mound Lab., Miamisburg, Ohio). Contract AT-33-1-GEN-53. Rev. Sci. Instrum., 40: 497-98(Mar. 1969).

The fabrication of high resolution silicon surface barrier detectors capable of being cooled to liquid nitrogen temperature and yielding linewidths of less than 10 keV for conversion-electron studies is described. (W.H.K.)

**17757** LIMITATIONS OF COMMERCIAL KRYPTON FOR PROPORTIONAL COUNTING. Clark, B. C.; Gross, W. (Columbia Univ., New York). Contract AT-(30-1)2740. Rev. Sci. Instrum., 40: 504-5(Mar. 1969).

A krypton–methane mixture was used in a gas flow proportional counter for measuring the energy distribution of photons from a soft x-ray generator. The background was found to be very high, and it was concluded that the use of krypton-85 is impractical for low-level counting. (W.H.K.)

**17758** HOLE DETECTION IN POLYMER FILMS AND IN PLASTIC TRACK DETECTORS. Blok, J.; Humphrey, J. S. Jr.; Nichols, G. E. (General Electric Research and Development Center, Schenectady, N. Y.). Rev. Sci. Instrum., 40: 509(Mar. 1969).

A method for rapidly detecting the holes due to the charged particle in thin sheets of plastic track detectors is described. The method consists of placing the polymer in contact with a sheet of Ozalid paper and passing the pair slowly through the ammonia stage of a conventional Ozalid machine. (W.H.K.)

**17759** ION IMPLANTATION IN SEMICONDUCTORS: LATTICE DISORDER AND ELECTRICAL EFFECTS. Mayer, James W. (California Inst. of Tech., Pasadena). IEEE (Inst. Elec. Electron. Eng.), Trans. Nucl. Sci., NS-15: No. 6, 10-21 (Dec. 1968).

From Annual Conference on Nuclear and Space Radiation Effects, Missoula, Mont. See CONF-680706.

Ion implantation techniques have been used to form p-n junctions and device structures. The anneal characteristics are influenced by reordering of the lattice, radiation damage effects, and the lattice location of the implanted species. Hall effect and channeling techniques have been used to evaluate the nature of the implanted layer. Anneal data suggest that there is similarity in the disorder produced in ion implanted and fast neutron irradiated silicon. In both cases, localized regions of disorder are produced around the track of the incident ion or recoil lattice atom. The nature of the disordered region has not yet been defined. In ion implanted samples at doses $\gtrsim 10^{14}/cm^2$ at room temperature an amorphous layer is formed which anneals at significantly higher temperatures than the isolated regions of disorder produced at lower doses. In annealed samples, Group V dopant atoms occupy substitutional sites while Group III elements have a significant fraction on regular interstitial sites. Hall measurements on implanted samples also reveal differences between Group III and V dopant elements. One of the difficulties experienced in evaluating the electrical characteristics of implanted layers is that the anneal temperatures lie above the range of studies on fast neutron irradiated silicon. (auth)

**17760** THE CHARACTERISTICS OF CROSS-SECTION DETECTORS WITH GAS IONIZED BY BETA PARTICLES OF TRITIUM, $^{85}Kr$, AND $^{63}Ni$. Lasa, Jan; Lesniewska, Barbara (Inst. of Nuclear Research, Krakow. Inst. of Nuclear Technique, Krakow). Chem. Anal. (Warsaw), 13: 1247-54(1968). (In Polish).

Cross-section detectors in which beta radiation of tritium, $^{85}Kr$, and $^{63}Ni$ and x-radiation are used as ionizing agents are described. The relation between the detector signal and the concentration of the examined substance in the carrier gas was investigated and the corresponding curves for nitrogen, oxygen, argon, carbon dioxide and carbon oxide are presented. The comparison of the detector parameters such as: the values of ionization currents, the random noise level, sensitivity, minimum detectable quantity and the linear range is given. The dependence of ionization current on the flow rate of gas passing through the detector is also pointed out. The influence of radioisotope type used as the ionizing radiation source on the detector properties and possibilities of detector applications are discussed. (auth)

**17761** LEAK TESTING SEALED SOURCES OF $^{226}Ra$ BY RADON PHOTOGRAPHY. Gels, G. L.; Bedrosian, P. H. (Southeastern Radiological Health Lab., Montgomery, Ala.). Health Phys., 16: 497-501(Apr. 1969).

The advantages of the method described include short testing time, low cost, high sensitivity, permanence of data, freedom from electronic problems, and 10 sec film development. The minimum detectable integrated exposure was found to be less than 500 pCi-hr of $^{222}Rn$ leakage. A plot is made of the minimum detectable leak rate vs. time of test. (auth)

**17762** APERTURE-INDEXED COLLIMATORS FOR GAMMA CAMERAS WITH SEMICONDUCTOR DETECTOR ARRAYS. Beach, A. D. (Atomic Weapons Research Establishment, Aldermaston, Eng.). J. Phys., E (London), 2: 378-80(Mar. 1969).

Gamma detector arrays, in the form of precut mosaics on single blocks of semiconductor material, are being considered for use in nuclear medicine, but have generated a collimator aperture-indexing problem, because of the need to match the coordinates of each aperture and detector element. A proven technique is described for the production of an aperture-indexed collimator, and other methods are suggested that may prove applicable. (auth)

**17763** SLIDE PROJECTOR AS AN INEXPENSIVE AUTOMATIC SAMPLE CHANGER FOR RADIOACTIVITY MEASUREMENTS. Knutsen, Gjert (Univ., Bergen). Lab. Pract., 18: 164(Feb. 1969).

For counting samples of radioactively labelled ($^{14}C$) cells on membrane filters and of evaporated liquid samples on rimless planchets, an automatic sample changer was constructed from an ordinary slide projector. Its construction and method of use are described. With this sample changer a stable background of 30 c.p.m. was achieved, and no influence on the counting by the other samples in the slide tray was found with $^{14}C$ as the isotope. With more energetic isotopes more efficient shielding from these samples may be required, and even a closure of the slot where the slides are taken into the projector might be necessary. The sample changer has run trouble free continuously for more than five months. (auth)

**17764** LOW-LEVEL COUNTING BY LIQUID SCINTILLATION. I. TRITIUM MEASUREMENT IN HOMOGENEOUS SYSTEMS. Moghissi, A. A.; Kelley, H. L.; Regnier, J. E.; Carter, M. W. (Southeastern Radiological Health Lab., Montgomery, Ala.). Int. J. Appl. Radiat. Isotop., 20: 145-56(Mar. 1969).

The significant factors which affect low-level counting of tritium by liquid scintillation were investigated. In a typical operating mode of the system, having a background of 8.5 counts/min, one count/min above background corresponds to 380 pCi/l of water (120 T.R. (ratio $^3H : ^1H = 1 : 10^{18}$)). The developed system combines convenience of automatic sample counting, room temperature operation, high efficiency, high capacity, and simplicity for effec-

tive application in measuring tritium levels in environmental samples. (auth) (UK)

**17765** THE CORRECTION FOR THE GAMMA SENSITIVITY OF A 4π COINCIDENCE COUNTER AS A FUNCTION OF THE GAMMA DISCRIMINATION LEVEL MEASURED FOR $^{54}$Mn AND $^{60}$Co. Lowenthal, G. C. (Australian Atomic Energy Commission Research Establishment, Lucas Heights, New South Wales). Int. J. Appl. Radiat. Isotop., 20: 196-9(Mar. 1969).

When the decay of a radionuclide is followed by gamma emission, the results of absolute radioactivity measurements by 4π counting must be corrected for gamma interactions in the counter as well as for other effects. If the $4\pi(\beta, X, A) - \gamma$ coincidence method is used for the measurements, the magnitude of the correction depends on $D_\gamma$, the discrimination level in the gamma channel, as well as on $e_{\beta\gamma}$, the efficiency of the 4π counter for gammas. This in turn depends on the physical characteristics of the source and the counter assembly. The current procedure for measuring this decay scheme correction is due to Williams and Campion (loc. cit. 14: 533(1963)). By making measurements with the response of the gamma counter restricted to the photopeak of highest energy, in appropriate cases C (correction term) = $e_{\beta\gamma}$. Sufficient results have been published to establish $e_{\beta\gamma}$ as a function of the gamma energy for many commonly used radionuclides and counters. However, accurate counting is often done at gamma discrimination levels well below the highest photopeak energy and $e_{\beta\gamma}$ is then by itself insufficient to determine C. In the work reported $^{54}$Mn and $^{60}$Co were each counted for a series of $D_\gamma$ values, starting with $D_\gamma = 0.03$ MeV, and it is shown that the correction term C can be expressed as a linear function of $D_\gamma$. (auth) (UK)

**17766** SPECTROMETRY OF THE CHARACTERISTIC X RADIATION EXCITED BY SOURCES EMITTING β RADIATION. Voljin, Valentina (Univ. of Bucharest). Rev. Roum. Phys., 13: 559-70(1968). (In Rumanian).

The best experimental conditions for the detection of characteristic x radiation excited by sources emitting beta particles were established by using scintillation detectors for qualitative and quantitative spectral analysis. For the preparation of these sources pure beta-emitting radioisotopes were used. The sources were constructed in different geometries according to their purpose. All the phenomena producing a deformation of the peak were taken into consideration: the background, the bremsstrahlung, Compton effect, and the escape peak. For a better monochromatization of the peak, the filter method was used. It was concluded that the samples with $Z > 40$ can be analyzed by the scintillation method. The qualitative analyses can be made for samples with 1 to 3 components having $\Delta Z = 6$ to 8. This method was applied both for the determination of small quantities of lead in atmospheric air and for the analysis of impurities. (tr-auth)

**17767** OWEN'S SPACE CHARGE METHOD AS AN OPTIMUM TECHNIQUE OF PARTICLE DISCRIMINATION AT LOW ENERGIES. Jentsch, W.; Wiesner, K. (Institut fuer Experimentelle Kernphysik, Pirna-Copitz, Ger.). Kernenergie, 11: 290-2(Nov.-Dec. 1968). (In German).

When using stilbene scintillators in connection with a photomultiplier of the K 14 FS 50 type, the threshold energy for neutron-gamma discrimination theoretically expected is about $E\gamma \approx 35$ keV. On the other hand, by using Owen's space charge method, a discrimination threshold of about $E\gamma \approx 15$ keV has experimentally been obtained. This discrepancy is discussed. (auth)

**17768** LUMINESCENCE DAMPING AND LOW-TEMPERATURE SENSITIVITY OF NUCLEAR PHOTOGRAPHIC EMULSIONS. Belous, V. M.; Kartuzhanskii, A. L.; Matvienko, V. I.; Shur, L. I. (Odessa Naval Engineering School. Leningrad Inst. of Soviet Commerce). Zh. Nauch. Prikl. Fotogr. Kinemotogr., 13: 457-9(Nov.-Dec. 1968). (In Russian).

Results and brief analysis are given of the parallel studies of luminescence and photographic properties of nuclear emulsions of P, Y-2, and A-2 types with effective acceptor holes introduced by tricarbocyanine I and II dyes. The luminescence spectra at 77°K was used to determine photographically the damping index $\mu = (I_0 - I)/I_0$ (index 0 is the control emulsion without a damper). The sensitivity S determined in a device with $^{233}$U α source was used to find the index of S conservation in the temperature range from room temperature to nitrogen: $\kappa = S_{77}/S_{293}$ and the difference $\kappa - \kappa_0$. Data obtained for $\mu$ and $\kappa - \kappa_0$ are tabulated and analyzed to determine the low-temperature sensitization of nuclear photographic luminescence of AgBr(I) emulsion by various sensitizers. (R.V.J.)

**17769** SPECTRUM OF PHOTONS FROM DISCHARGE OF ARGON-ALCOHOL GEIGER COUNTER. Schmid, H. (Univ., Muenster, Ger.). Z. Phys., 221: 175-85(1969). (In German).

The absolute intensity and the spectrum of the visible and ultraviolet radiation from the discharge of a self-quenching Geiger–Müller counter was investigated between 2,200 and 6,500 A. Because of the extremely weak radiation during the growth of the avalanches, an extremely sensitive optical spectrometer set-up was built, which was able to detect single photons from the counter discharge in small wavelength intervals. The intensity and spectrum of the discharge light was measured. Lines of neutral and single-ionized argon were identified. The main intensity was found for wavelengths above 3,100 Å, but no lines below 2,800 Å. For large overvoltages, a weak continuum appeared between 2,300 and 2,800 Å. (auth)

**17770** SILICON SOLID-STATE DETECTOR PRODUCED BY LITHIUM ION IMPLANTATION. Lee, Chul Chu (Yonsei Univ., Seoul); Ko, Youn Kyu; Kim, Do Kyong; Sun, Kwang Youl. J. Korean Phys. Soc. 1: 90-6(Oct. 1968).

Investigations were performed on the lithium ion implantation method of producing silicon p-n junction detectors. Ion energies of up to 20 keV were used to get shallow junctions in high resistivity, 5,000 ohm-cm p-type silicon and uniform implantation with ion concentrations of up to $10^{19}$ ions/cm$^3$ for Li were secured on a rotating target. Details of the construction methods and some I-V characteristics of the detectors are presented. The resolution of the detector was 1.4% at ambient temperature thus confirming the possibility of making a nuclear particle detector by the lithium ion implantation technique. (auth)

**17771** IMPROVED CdTe FOR GAMMA DETECTION BETWEEN -100 AND +100°C. Zanio, Kenneth R. (Hughes Research Labs., Malibu, Calif.). Appl. Phys. Lett., 14: 56-8 (Jan. 15, 1969).

Mobility-trapping time $\mu\tau^+$ products of $2 \times 10^{-4}$ cm$^2$/V for electrons and $3 \times 10^{-5}$ cm$^2$/V for holes have been found in semi-insulating cadmium telluride using transient response techniques. This represents a tenfold and fourfold increase in the $\mu\tau^+$ product of holes and electrons, respectively. The $^{60}$Co response of surface barrier devices fabricated from this material indicates that gamma detection is possible over the extended temperature range of −100° to +100°C. Encapsulation techniques have been developed to prevent the degradation of these devices from the ambient atmosphere. (auth)

**17772** BACKGROUND, PEAK EFFICIENCY, AND DIMENSIONS OF NaI(Tl)-CRYSTALS. Courbois, Th.; Van Gelderen, L.; Leutz, H. (Harshaw Chemie, De Meern, Netherlands). Nucl. Instrum. Methods, 69: 93-100(Mar. 1969).

Background counting rates of NaI(Tl)-crystals shielded with 15 cm Fe, 10 cm Pb and 0.5 cm Cu and ranging in size from 1" dia. × 1" height to 8" dia. × 4" height were measured in the energy region between 0.2 and 4 MeV. The results indicate that background counting rates observed without anticoincidence protection depend more simply on crystal geometrical cross section than on crystal surface or crystal volume. Total absorption peak efficiencies were evaluated with Monte Carlo calculations and by making use of experimental results on peak/total ratios. Based on the measured background and on the evaluated peak efficiencies the minimum counting times necessary for peak separation from background were normalized on the 8" dia. × 4" height-crystal and plotted vs energy of incident gamma quanta for different crystal sizes and for source distances of 10 cm, 30 cm and 50 cm. (auth)

**17773** DIGITISATION OF NEON FLASH TUBES. Ayre, C. A.; Thompson, M. G. (Univ. of Durham, Eng.). Nucl. Instrum. Methods, 69: 106-8(Mar. 1969).

A new technique for the digitisation of the information from neon flash tubes is described. The technique utilizes a simple probe to detect a change in potential along the axis of the tube when it discharges. The mechanism by which the potential changes is discussed briefly. (auth)

**17774** A PULSE-HEIGHT COMPENSATION SYSTEM FOR Ge(Li) TIMING. Jaklevic, J. M.; Bernthal, F. M.; Radeloff, J. O.; Landis, D. A. (Univ. of California, Berkeley). Nucl. Instrum. Methods, 69: 109-14(Mar. 1969).

A simple pulse-height compensation system for correcting the energy walk of Ge(Li) fast-timing data is described. The results of the method, applied to a number of different Ge(Li) detectors, are presented. A factor-of-two improvement in time resolution was found to be possible in all cases. (auth)

**17775** ANTI-COINCIDENCE SHIELDING USING NaI(Tl) OFFCUTS. Jones, B. W. (Wills Physics Lab., Bristol, Eng.). Nucl. Instrum. Methods, 69: 136-40(Mar. 1969).

The response to 0.661 MeV gamma radiation of crushed NaI(Tl) in carbon tetrachloride, α-bromo-benzene, carbon-disulphide and α-bromo-naphthalene was studied. The optical constants of the liquids have been determined so that the importance of the systems' various parameters could be assessed. (auth)

**17776** MULTICOUNTER EQUIPMENT FOR MEASURING ANGULAR CORRELATIONS. Gorodetzky, S.; Beck, F. A.; Engelstein, P.; Byrski, T.; Knipper, A. (Centre de Recherches Nucleaires, Strasbourg). Nucl. Instrum. Methods, 69: 163-9 (Mar. 1969). (In French).

A seven detectors, NaI 3" × 3", multicounter goniometer has been realized and tested for the measurements of $\gamma-\gamma$ angular correlations. It allows the simultaneous measurement, on a single 4096 multichannel analyzer, of 30 free angles of the $W(\theta_1, \theta_2, \phi)$ function in nuclear reaction (or of the seven geometries defined by Litherland and Ferguson) and of seven free angles of the $W(\theta)$ function in radioactive decay. Angular distribution and particle-$\gamma$ angular correlations can also be measured with this apparatus. This system has been tested in $^{60}Co$, $^{106}Ru$ and $^{207}Bi$ decay, and in $^{12}C(^3He,p)^{14}N$, $^{25}Mg(p,p')$ and $^{53}Cr(p,n)^{53}Mn$ nuclear reactions. (auth)

**17777** EFFECT OF FINITE TIME-RESOLUTION ON PERTURBED ANGULAR CORRELATION MEASUREMENTS. Beraud, R.; Berkes, I.; Daniere, J.; Marest, G.; Rougny, R. (Univ. de Lyon, Villeurbanne, France). Nucl. Instrum. Methods, 69: 41-4 (Mar. 1969).

The distortion of differential perturbed angular correlation by finite time-resolution is calculated in an analytic way. A detailed analysis is given on the perturbation function $G_2(t)$ for $j = 5/2$ intermediate spin. (auth)

**17778** SIMPLE HIGH RESOLUTION PULSE SHAPE DISCRIMINATOR. Onge, R. N. St.; Lockwood, J. A. (Univ. of New Hampshire, Durham). Nucl. Instrum. Methods, 69: 25-8 (Mar. 1969).

A pulse shape discrimination system has been developed with the following characteristics: high multi-particle resolution ($M \approx 3$), wide dynamic range ($1 < E_n < 30$ MeV), simplicity, passiveness, stability, high-count-rate capability (>50 kHz), built-in calibration, minimum weight (<20 g) and low power consumption. This system simultaneously extracts the separate gamma-ray and neutron pulse height spectra. The sample data presented were obtained with NE213 liquid scintillators, RCA 8575 photomultipliers, and two-parameter pulse height analyzers. (auth)

**17779** CONTINUOUS MEASUREMENT OF $^{14}C$-LABELED SUBSTRATE OXIDATION TO $^{14}CO_2$ BY ISOLATED TISSUES: AN IONIZATION CHAMBER METHOD. Davidson, Warren D.; Schwabe, Arthur D.; Thompson, James C. (Univ. of California, Los Angeles. Harbor General Hospital, Torrance, Calif.). Anal. Biochem., 26: 341-9(Dec. 1968).

An adaptation of the vibrating reed electrometer and ionization chamber is described for the continuous measurement of carbon-14-labeled substrate oxidation to $^{14}CO_2$ by isolated tissues. Substrate oxidation curves are given for rat renal cortex and epididymal fat pad, frog gastric mucosa, and human erythrocytes. (W.H.K.)

**17780** DEVELOPMENT OF END-WINDOW TYPE SELF-QUENCHING G. M. COUNTERS. Dutt, J. C. (Atomic Energy Centre, Dacca, Pakistan); Huq, M. S.; Jalil, A. Nucl. Sci. Appl., Ser. B, 4: 13-21(Oct. 1968).

An end-window type self-quenching Geiger–Muller counter is described. It has been observed that ethylalcohol is a better quenching agent than methane. A total pressure of 10 cm of Hg with partial pressures in the ratio 9:1 of main tube filling gas to the quenching gas is the best. (auth)

**17781** LUNAR SURFACE SOLAR WIND SPECTROMETER. Wiser, Herbert L. (Electro-Optical Systems, Inc., Pasadena, Calif.); Synder, Conway W.; Takahashi, George M. ISA (Instrum. Soc. Amer.), Proc., Nat. Aerosp. Instrum. Symp., 13th, San Diego, 1967, 289-96(1967),

From 13th National Aerospace Instrumentation Symposium, San Diego, Calif. See CONF-670658.

A system for measuring charged solar particle types, energies, fluxes, and directions on the lunar surface is described. The sensor assembly consists of seven gridded Faraday cups. (W.H.K.)

**17782** A BLOCK FOR INTERCEPTION AND COLOR SCANNING FOR THE GAMMA-TOPOGRAPH GT-60. Khripta, F. P.; Parish, N. Z. (Scientific-Research Inst. of Roentgen-Radiology and Oncology, Kiev). Med. Radiol., 14: No. 2, 53-7(Feb. 1969). (In Russian).

A device for increasing the contrast of the scannogram and color staining (two colors) of regions with a diverse degree of isotope accumulation is described. This augments the resolving capacity of the T-60 scanner, thus elevating its diagnostic possibilities, and simplifying and accelerating the investigation by 2 to 3 times. A detailed technical description is given. (auth)

## *Nuclear Spectroscopic Instrumentation*

*Refer also to abstracts 19187, 19253, and 19254.*

**17783** (BLG-425, Paper 1) SOME FUNDAMENTAL REMARKS ON Ge(Li) DETECTORS. Fettweis, P. (Centre d'Etude de l'Energie Nucleaire, [Brussels] (Belgium)). 15p.

A description of the operation of lithium-drifted germanium detectors for gamma spectroscopy is presented. The fundamental properties and operation of the lithium-drifted germanium detectors are compared to those of an ionization chamber. (W.H.K.)

**17784** (BLG-425, Paper 4) THE USE OF Ge(Li) DETECTORS IN NUCLEAR PHYSICS. Vervier, J. (Centre d'Etude de l'Energie Nucleaire, Mol (Belgium)). 23p.

The use of lithium-drifted germanium detectors in the study of the decay of radioisotopes, thermal-neutron capture gamma rays, gamma rays from nuclear reactions, and mesonic x-rays is reviewed. (W.H.K.)

**17785** (BLG-425, Paper 5) A NEW Ge(Li)-SPECTROMETER FOR THE DETERMINATION OF BURN-UP OF REACTOR FUEL ELEMENTS. Hick, H.; Pepelnik, R. (Oesterreichische Studiengesellschaft fuer Atomenergie G.m.b.H., Seibersdorf). 15p.

The design and operation of an improved summing lithium-drifted germanium Compton spectrometer are briefly discussed. (W.H.K.)

**17786** (CEA-CONF-1112) GAMMA SPECTROMETRY ON AN EXIT CHANNEL OF A REACTOR. Gailliard, Jean-Pierre (Commissariat a l'Energie Atomique, Grenoble (France). Centre d'Etudes Nucleaires). Sept. 1968. 11p. (In French). (CONF-680944-1). Dep.

From 24th Conference of the Euratom Dosimetry Groups, Brussels, Belgium.

A detailed description of a thallium activated sodium iodide gamma spectrometer for use in a test facility of a research reactor is given; a schematic of the spectrometer is included. The spectrometer utilizes signals from various crystals to measure the photoelectric effect, Compton Effect, and pair production. Utilization of the spectrometer in the Siloette is described briefly. Results of the Siloette measurements are shown graphically. (M.L.S.)

**17787** (CEA-R-3692) USE OF A URANIUM ORE FOR THE OVERALL CALIBRATION OF GAMMA SPECTROMETERS. Robert, Marcelo (Commissariat a l'Energie Atomique, Saclay (France). Centre d'Etudes Nucleaires). Dec. 1968. 61p. (In French). Dep.

In analytical laboratories using $\gamma$ spectrometry, the need for a range of standards has led to the study of sources made up of a mineral ore with a view to its exclusive use for the overall calibration of the measurement equipment. The ore used has a relatively low specific activity, thus avoiding large self-absorption corrections at low energies. The analysis is carried out using a junction of average characteristics. (auth)

**17788** (CEA-R-3700) SPECTROMETER FOR COSMIC AND SOLAR PROTONS EXPERIMENT S 72 ABOARD THE SATELLITE ESRO II. Amram, Yves; Detourne, Guy; Hugot, Christian; Malaval, Pierre; Andrejol, Jacques; Axisa, Francois; Engelmann, Jacques; Koch, Lydie (Commissariat a l'Energie Atomique, Saclay (France). Centre d'Etudes Nucleaires). Dec. 1968. 87p. (In French). Dep.

An experiment designed for the spectrometry of charged particles, and intended for the European satellite ESRO II, the launch of which is planned for May 1968, is described. The polar orbit of this satellite will enable the experiment to measure, depending on the geomagnetic latitude, either the energy of solar protons, or the spectrum of the protons of the internal Van Allen belt, or even the spectrum of the abundance of galactic nuclei whose charge is smaller than 6. The equipment is built in two parts: a sensor including a telescope of solid state detectors of large area (lithium drifted silicon) and the preamplifiers; and an electronic unit including the amplifiers, the pulse height discriminators and the coincidence circuits, the analog-to-digital converter which encodes the energy loss of an incident particle in one of the detectors, the scaler for counting the flux of the particles, and the interface to the telemetry system of the satellite. The equipment weights 1350 grams, drains 350 mW and is designed for normal operation from −20°C to +50°C. Design principles, a description of the circuits and their operation, and requirements specific to space electronics are described including lightness, low power drain, vibration strength, wide range of working temperatures, and above all reliability. The modifications brought to the flight model F2 after the failure of the launch of the model F1 in May 1967 are also reported. (auth)

**17789** (INSJ-109) REACTION ELECTRON AND GAMMA-SPECTROSCOPY, PRESENT STATUS AND A PERSPECTIVE OF ITS FUTURE DEVELOPMENT. Sakai, Mitsuo (Tokyo Univ. (Japan). Inst. for Nuclear Study). Sept. 1, 1968. 50p. (CONF-680702-7). Dep.

From International Symposium on Nuclear Structure, Dubna, USSR.

Experimental procedures and theoretical background in reaction electron and gamma spectroscopy are reviewed, and some examples are presented. As an application of the technique in rather low-energy reactions, the gamma-ray spectroscopy of proton capture in which the nuclear reaction proceeds via an isobaric analog state is described, and its physical meaning is illustrated. Timing methods and several topics are mentioned as new research fields of this technique. (auth)

**17790** A 4π BETA SPECTROMETER USING SOLID STATE DETECTORS. Trischuk, J.; Kankeleit, E. (California Inst. of Tech., Pasadena). Nucl. Instrum. Methods, 66: 197-201(Dec. 15, 1968).

A solid-state beta spectrometer using silicon detectors in 4π geometry is described. The properties of the spectrometer are examined. The beta spectrum of $^{32}P$ measured is found to agree with magnetic spectrometer measurements. Correlations between the parameters describing the shape of the beta spectrum are discussed. (auth)

**17791** DETERMINATION OF MEGA-VOLT ELECTRON SPECTRA FROM DOSE DEPOSITION PROFILES. Rauch, J. E. (Lockheed Missiles and Space Co., Palo Alto, Calif.). IEEE (Inst. Elec. Electron. Eng.), Trans. Nucl. Sci., NS-15: No. 6, 322-35(Dec. 1968).

From Annual Conference on Nuclear and Space Radiation Effects, Missoula, Mont. See CONF-680706.

First, the equations are developed which are needed to compute a dose deposition profile from a given electron spectrum. The dissipation distribution in aluminum as a function of electron energy is considered as the fundamental parameter used in the calculation. Modified Nakai values of the dissipation distributions are used. Next, a brief account of the actual calculations used in the computer program is presented with a sample case for illustration. The uniqueness of the spectral determination is discussed by considering the results obtained by three different initial spectra. Although the final spectra are different and contain many of the properties of their respective initial spectra, the calculated doses correspond to the measured doses extremely well and the same mean electron energy is obtained in all three cases. The use of the resulting three final spectra for the calculation of dose deposition in high atomic number materials is illustrated by showing comparison deposition calculations in aluminum and tantalum for the three spectra. The agreement of the calculated dose deposition for the three spectra is very good. Finally, an appendix is included on the experimental measurement of dose from a pulsed electron source using thin calorimeters and blue cellophane. (auth)

**17792** MEASUREMENT OF LINAC THICK-TARGET BREMSSTRAHLUNG SPECTRA USING A LARGE NaI SCINTILLATION SPECTROMETER. Sandifer, C. W.; Taherzadeh, M. (EG and G, Inc., Goleta, Calif.). IEEE (Inst. Elec. Electron. Eng.), Trans. Nucl. Sci., NS-15: No. 6, 336-45(Dec. 1968).

From Annual Conference on Nuclear and Space Radiation Effects, Missoula, Mont. See CONF-680706.

Thick-target bremsstrahlung spectra produced by electron bombardment of a 0.2 radiation-length gold-tungsten target were measured for electron energies in the range of 5.3 to 20.9 MeV. A large NaI spectrometer coupled to a pulse pile-up rejection system measured pulse-height distributions for bremsstrahlung emitted in the forward direction, and a response matrix developed for the spectrometer was used to convert the pulse-height distributions into photon energy spectra. The shapes of the measured spectra show good agreement with those obtained by others for the same target configuration. Apparatus and experimental methods are described and thick-target bremsstrahlung spectra are presented for electron energies of 5.3, 10.0, 14.8, 16.4, 18.2, and 20.9 MeV. (auth)

**17793** APPARATUS FOR CONTROLLING THE ENTRY OF INFORMATION INTO A STORAGE ARRANGEMENT. (to Kozponti Fizikai Kutato Intezet). British Patent 1,139,077. Jan. 8, 1969. Priority date Feb. 18, 1965, Hungary.

A multichannel time interval analyzer which comprises a memory or storage arrangement, the storage arrangement having a plurality of storage channels sequentially selecting events which occur at a particular time interval after a predetermined reference point and recording the events in particular channels predesignated for that time interval, is described. The analyzer can be used in time-of-flight neutron spectroscopy. (B.G.D.)

**17794** A Ge(Li) TWO CRYSTAL COMPTON SPECTROMETER. Broude, C.; Haeusser, O.; Malm, H.; Sharpey-Schafer, J. F.; Alexander, T. K. (Chalk River Nuclear Labs., Ont.). Nucl. Instrum. Methods, 69: 29-34(Mar. 1969).

The performance of Compton spectrometers using two Ge(Li) gamma-ray detectors is demonstrated. Two different configurations of detectors have been used, together with on-line computer methods to show that a nearly-single-peak spectrum of good resolution can be obtained for a monochromatic gamma ray. Further, the peak is due to purely single Compton scattering of well determined scattering angle despite the large solid angles of the scattering and detecting crystals. These considerations make the device well suited to use as a gamma-ray polarimeter. (auth)

**17795** EFFICIENCY OF NEUTRON CRYSTAL MONOCHROMATORS. Popovici, M.; Gheorghiu, Z.; Gelberg, D. (Inst. for Atomic Physics, Bucharest). Nucl. Instrum. Methods, 69: 125-30(Mar. 1969).

The optimization of neutron crystal monochromators is discussed. Experimental results concerning the efficiency of lead single-crystals are reported. (auth)

**17796** THICK RADIATOR FAST-NEUTRON SPECTROMETER. Geller, K. N. (Drexel Inst. of Tech., Philadelphia); Eccleshall, D.; Bardin, T. T. Nucl. Instrum. Methods, 69: 141-54(Mar. 1969).

A thick radiator fast-neutron spectrometer patterned after the device originally constructed by Calvert, Jaffe and Maslin is described. Modifications introduced in the present counter and the use of modern data acquisition and analysis techniques lead to an appreciable improvement in energy resolution. Energy resolutions of better than 5% are realized for neutron energies greater than 10 MeV. Detailed analysis of the spectrometer efficiency, resolution and line shape is presented. (auth)

## *High Energy Physics Instrumentation*

**17797** (AD-661754) APPARATUS FOR MEASURING THE INTENSITY OF COSMIC RAYS AT GREAT DEPTHS. Vavilov, Yu. N.; Nelepo, B. A.; Pugacheva, G. I.; Fedorov, V. M. Translated from Tr. Morsk. Gidrofiz. Inst., Akad. Nauk Ukr. SSR, 36: 31-6(1966). 9p. (NOO-Trans-378). CFSTI.

The use of a Cherenkov detector is suggested for the measurement of intensity of mu-mesons at great depths. The detector was tested in the Black Sea at depths as great as 1 km. A diagram shows the recorded impulses. Some of the calculated values are tabulated to show the expected global intensity to depths of 5 km which had been calculated with the aid of theoretically derived ratios for the vertical intensity of mu-mesons. (auth) (USGRDR)

**17798** (HUX-2752-39) SPASM: A PROGRAMMED CRT PRECISION SCANNING AND MEASURING SYSTEM. Brenner, A. E.; deBruyne, P.; Reuter, B. J.; Sisterson, L. K. (Harvard Univ., Cambridge, Mass. Dept. of Physics); Bordner, C. A. Jr. (Colorado Coll., Colorado Springs. Dept. of Physics. Harvard Univ., Cambridge, Mass. Dept. of Physics). Oct. 1968. Contract AT(30-1)-2752. 18p. (CONF-681025-13). Dep. CFSTI.

From International Conference on Advanced Data Processing for Bubble and Spark Chambers, Argonne, Ill.

The SPASM (spark chamber photograph automatic scanning and measuring) system which is a precision programmed CRT scanning and measuring system for particle track measurements on both spark chamber and bubble chamber film is described. (W.H.K.)

**17799** 500 LITER HYDROGEN BUBBLE CHAMBER. Pless, I. A.; Bailey, B. M.; Biron, R. D.; Karageorge, G. K. (Massachusetts Inst. of Tech., Cambridge). Contract AT(30-1)-2098. Rev. Sci. Instrum., 40: 397-409(Mar. 1969).

A bubble chamber designed to operate with 500 visible liters of liquid hydrogen has been tested for performance with liquid nitrogen at Argonne National Laboratory. It features unique systems for controlling chamber overpressure and minimizing thermal gradients within the working liquid. Refrigeration requirements were determined for the full range of operating conditions from static to expansion-pulsing at a rate of 3/sec at intervals ranging from 333 msec down to 125 msec. (auth)

**17800** DEVELOPMENT OF INCLINED SPARKS IN A TRACK-FOLLOWING SPARK CHAMBER. Evans, C. J. (CERN, Geneva). Nucl. Instrum. Methods, 69: 61-9(Mar. 1969).

A theoretical investigation into the phenomenon of electrical breakdown along particle trajectories in a wide gap spark chamber is described. The differential equations for ionization growth, written in a form which allows for the space-charge effects of a number of adjacent electron avalanches, are solved numerically using a second-order iterative method. The results show that the development of the inclined spark can be explained on the basis of

known values of the primary ionization coefficient, electron drift velocity and diffusion coefficient. Some results for a single avalanche are also given for comparison. (auth)

**17801** LIQUID HYDROGEN TARGET WITH INTERACTION POINT LOCALIZATION BY CHERENKOV EFFECT. Bertolucci, E.; Mannelli, I.; Martorana, F.; Pierazzini, G.; Scribano, A.; Sergiampietri, F.; Vincelli, M. L. (Univ., Pisa, Italy. INFN, Pisa, Italy). Nucl. Instrum. Methods, 69: 21-4(Mar. 1969).

A liquid $H_2$ target with good collection of the Cherenkov light emitted by high energy pions has been recently tested at the CERN PS. When the incoming $\pi^-$ makes an interaction with a completely neutral final state, the amount of light emitted depends on the length of the pion path from the entrance window to the interaction point. Therefore a measurement of the light gives information on the location of the interaction along the target. The resolution obtained with a 20 cm long target is about 3 cm fwhm. (auth)

**17802** ON A POSSIBILITY FOR THE REGISTRATION OF $K^+$-MESONS. Lorikyan, M. P. (Inst. of Physics, Erevan). Izv. Akad. Nauk Arm. SSR, Ser. Fiz., 3: 222-3(1968). (In Russian).

A simple method for the registration of $K^+$ mesons on accelerators using a Cherenkov detector is given. (auth)

## Radiation Dosimeters

*Refer also to abstracts 17791 and 18019.*

**17803** (AD-672563) CALORIMETER WITH INTERCHANGEABLE ABSORBERS FOR ABSORBED DOSE MEASUREMENTS. Goldstein, Norman (Naval Radiological Defense Lab., San Francisco, Calif.). June 14, 1968. 15p. (USNRDL-TR-68-52). CFSTI.

A calorimeter for measuring absorbed dose is described that has interchangeable absorbers which can be placed within 2 cm of the source of radiation. The isothermal environment is maintained with boiling liquid nitrogen and a thermal switch permits rapid cooling of the detector. Absorbed dose measurements for four absorbers, C, Al, Si, and Ge, are presented. Exposures at a 250 kV constant potential x-ray machine are compared to calculated values at four effective energies, 35, 65, 110, and 180 keV. (auth) (USGRDR)

**17804** (EGG-1183-2207) A REVIEW OF SOME PASSIVE DOSIMETRY METHODS USED IN RADIATION EFFECTS STUDIES WITH FAST BURST REACTORS. Technical Paper Number S-50-TP. Humpherys, K. C. (EG and G, Inc., Santa Barbara, Calif.). Mar. 1969. 40p. (CONF-690102-4). Dep. CFSTI.

From Fast Burst Reactor National Topical Meeting, Albuquerque, N. Mex.

Some of the more important instruments and methods used to determine neutron fluence, neutron energy spectra, and gamma-ray dose during radiation effects experiments with fast burst reactors are described and evaluated. General radiation measurement problems encountered by radiation effects investigators are summarized, and the fundamental principles on which various measurement techniques are based are outlined. (auth)

**17805** (JAERI-5017, pp 143-8) RADIATION DOSIMETRY. (Japan Atomic Energy Research Inst., Tokyo). (In Japanese).

Studies on radiation physics are summarized. The macroscopic measure of interaction of radiation with tissues is the energy imparted per unit mass of material, which is known as the absorbed dose. However, as the volume of tissues becomes microscopic size, the energy imparted fluctuates from place to place by discrete losses of ionization. In order to study this problem, a theoretical work, in which the fluctuated energy was applied to the target theory in radiobiology, was carried out. Also, studies on measuring methods are described. A theoretical coherence on the multi-detector method was studied analytically. Furthermore, this method was applied to personnel dosimeters, which utilize thermal neutrons leaked out of the human body. For measurements of $\gamma$-rays, G(E) function of a large-size scintillator for the dose was determined with calculations by a computer. (auth)

**17806** (ORNL-TM-2154) FILM BADGE READER AND CARD PUNCH SYSTEM. Madden, E. (Oak Ridge National Lab., Tenn.). Jan. 30, 1969. 33p. Dep. CFSTI.

A film badge reader (FBR), designed to provide direct radiation exposure information from each of four absorber areas on the ORNL beta-gamma film dosimeter and to automatically punch this information on an IBM card, is described. An electromechanical arrangement sequentially positions a developed film from an ORNL film badge at each of the four absorber positions. A densitometer measures the optical density of the film at each position and provides a calibrated measurement that is representative of the radiation exposure received by the film. Each reading is displayed on a digital voltmeter and automatically punched on an IBM card. The film badge reader calibration procedures, operation procedures, circuit descriptions, modifications to hardware, and simplified operating instructions are presented. (auth)

**17807** THERMOLUMINESCENT DOSIMETRY. Cameron, J. R.; Suntharalingam, N.; Kenney, G. N. Madison, Wis., University of Wisconsin Press, 1968. 250p. $7.50.

Applications of thermoluminescent dosimeters (TLD), irradiation techniques, characteristics of TLD phosphors, instrumentation, milliroentgen exposures-measurements and applications, nonradiation-induced thermoluminescence, annealing characteristics of LiF, supralinearity of LiF, and some theoretical aspects of the thermoluminescence phenomena are discussed. Also, manufacturers of TLD equipment are listed, a simple design for a TLD reader is described, and an extensive bibliography is presented. (W.H.K.)

**17808** EMISSION SPECTRA OF THERMOLUMINESCENT LITHIUM FLUORIDE AND LITHIUM BORATE: MANGANESE. Ellis, S. C.; Rossiter, N. J. (National Physical Lab., Teddington, Eng.). Int. J. Appl. Radiat. Isotop., 20: 201-3(Mar. 1969).

The use of a system for the determination of the emission spectra of thermoluminescent phosphors above ambient temperature is described, based on a grating monochromator with photomultiplier detector and calibrated to correct for wavelength dependence of sensitivity. The system was used in the first instance for the common radiothermoluminescent phosphors lithium fluoride (TLD-100) and lithium borate: Mn. A standardized tungsten filament quartz-iodine lamp was used in order to determine the wavelength response of the detecting assembly. (auth)

**17809** STRAIN GAGE DOSIMETER FOR PULSED RADIATION ENVIRONMENT. Birdsall, R. L.; Binder, D.; Peffley, W. M. (Hughes Aircraft Co., Fullerton, Calif.). IEEE (Inst. Elec. Electron. Eng.), Trans. Nucl. Sci., NS-15: No. 6, 346-9 (Dec. 1968).

From Annual Conference on Nuclear and Space Radiation Effects, Missoula, Mont. See CONF-680706.

A new method of determining the energy absorbed in a material subjected to a nuclear radiation pulse is described in which the thermal expansion of the material is measured with a strain gage. The method is similar to calorimetry in concept but is not limited to materials with high thermal conductivity. The method has been tested in linac and pulsed reactor environments. Using polyethylene and Teflon as absorbers, separation of the neutron and gamma ray components of the dose from a pulsed reactor has been demonstrated. (auth)

**17810** PERSONAL DOSIMETER FOR NEUTRONS. Nicolae, Marieta; Pop, Rodica (Inst. of Atomic Physics, Bucharest). Rev. Roum. Phys., 13: 773-82(1968).

A dosimeter which comprises three dosimetric systems is described whereby the thermal neutron, $\gamma$ rays and fast neutron dosimetry may be carried out in a single badge. By choosing a suitable detecting material (photographic or solid detector) a large range may be covered in the field of current or accidental exposure doses. The first dosimetric system is the main system of this dosimeter. Using a pair of Orwo 3 + 4 dosimetric films and the filter arrangement Cd-0.7/Pb-0.3 mm + Sn-0.7/Pb-0.3 mm, it is possible to measure thermal neutron doses between 20 mrem and 100 rem and $\gamma$ rays exposures in the range 20 mrad to 100 rad. The second dosimetric system (for accidental exposure), comprises as detecting material a mica foil on which a determined amount of natural uranium was evaporated. This allows to measure thermal neutron flux between $10^9$ and $10^{12}$ n/cm$^2$ (1 to $10^3$ rem). This dosimetric system is less sensitive to thermal neutrons than the photographic one, but is easily handled and suitable for use in current dosimetry. The third dosimetric system, which comprises a nuclear emulsion sheet as photographic material, allows to measure fast neutron intensities in the range of current exposure in a field of $\gamma$ rays up to 10 rad. (auth)

**17811** A STUDY OF THE INDICATIONS OF THE SRP-2 RADIOMETER IN MEASUREMENTS OF THE DOSES OF X-RAYS AND GAMMA-RADIATION. Balon, Z. P.; Karpov, B. N. (Central Scientific -Research Inst. of Roentgen-Radiology, Leningrad). Med. Radiol., 14: No. 2, 58-60(Feb. 1969). (In Russian).

The relation between the indications of the SRP-2 radiometer and radiation energy was studied for the purpose of elucidating possible errors. The sensitivity of the apparatus is described. (auth)

## Radiometric Instruments

*Refer also to abstract 17709.*

**17812** (CEA-CONF-1185) NATURAL SELECTIVE GAMMA RADIOLOGGING. Czubek, J. A. (Institute of Nuclear Research, Krakow (Poland); Dumesnil, P. (Commissariat a l'Energie Atomique, Saclay (France). Centre d'Etudes Nucleaires). [nd]. 43p. (In French). (R-2652; SM-112/16; CONF-681117-1). Dep.

From Symposium on the Use of Nuclear Techniques in the Prospecting and Development of Mineral Resources, Buenos Aires, Argentina.

The radiometric measurement of uranium ores in drill holes can be done by natural $\gamma$ radiologging. A method for this logging is presented. It is based on the utilization of the increase of the absorption coefficient of the $\gamma$ photons by photoelectric effect resulting from the presence of uranium in the rock. The U should modify the form of the spectrum of the radiation scattered by the medium beginning with the primary radiation emitted by the radioactive nuclides present. By normalizing this modification by relating it to that obtained for a given specific activity, a parameter is obtained which is a function of the chemical composition of the rock in general and of its uranium content in particular. Laboratory and field tests were made of the method. The results showed that the uranium content can be determined independently of its equilibrium state and density. The minimum content detectable depends on the geological conditions of each deposit. Laboratory precisions of 10 to 20% can be obtained. To obtain this precision in the field it is necessary to use an electronic apparatus whose gain variations are held to ±1%. (tr-auth)

**17813** STUDIES ON THE DENSITY METER AND THE MOISTURE METER FOR CONTROL OF ROAD CONSTRUCTION. MEASUREMENTS OF SOIL DENSITY AND MOISTURE CONTENT WITH RADIOACTIVE ISOTOPES. Yamamoto, Moriyuki; Mizushina, Tomoyuki. Rep. Eng. Res. Dept., Taisei Constr. Co., Ltd. (Tokyo), No. 1, 125-40(July 1968). (In Japanese).

The $\gamma$-ray density meter detects scattering due to electrons from gamma irradiation of the ground with a Geiger–Mueller counter. The neutron moisture meter detects moderated neutrons due to elastic scattering of fast neutrons irradiated into ground using a $BF_3$ tube. There are two kinds of radioisotope (RI) measuring instruments, namely, the insert type and the surface type. The measurement is carried out by non-destructive methods, the time required for the measurement is short, complicated calculations are unnecessary, and personal error is not included in the measurement. The experiences of the Japan Road Public Corp. using RI measuring instruments for construction controls of Meishin highway are reported. During experiments in the laboratory, the plateau characteristic, frequency distribution of output, variation in source voltage, temperature variation, hourly and daily fluctuations of output were studied. Also, the experiments to draw calibration curves for the density meter of the back-scattering type and the neutron moisture meter, and comparison of measurements on the first construction site of the Tomei highway in Yokohama with the measurements by conventional methods were carried out. The forecast that the RI measuring instrument is usable for construction control at construction site was obtained from the results of the experiments. (NSA of Japan)

## Miscellaneous Instruments and Components

*Refer also to abstracts 17559, 17641, 17663–17665, and 19200.*

**17814** (CEA-CONF-1011) ULTRAFAST NUMERICAL SAMPLER FOR THE STUDY OF ELEMENTARY PHENOMENA IN IONIZED GASES. Felix, J. P.; Fernandes, C.; Jeudon, H. ([Commissariat a l'Energie Atomique, Paris (France)]). May 28, 1968. 11p. (In French). (CONF-680710-9; PA/RT-32). Dep.

From 5th Symposium on Fusion Technology, Oxford, England.

The preliminary design and construction of an ultrafast numerical sampler are described. The device consists of the signal sampler, the coder, and the numerical memory. Each of these constituents is described. (J.S.R.)

**17815** (CEA-CONF-1062) REDUNDANCE AND INDEPENDENCE OF ASSEMBLIES ASSOCIATED WITH THE PERFORMANCE OF A FUNCTION NECESSARY FOR THE RUNNING OF A REACTOR. Furet, Jacques (Commissariat a l'Energie Atomique, Saclay (France). Centre d'Etudes Nucleaires). Feb. 21, 1968. 13p. (In French). (CONF-680643-1). Dep.

From Conference on Stability of the Power Supply to Nuclear Reactor, Ispra, Italy.

A probabilistic approach to determining go/no-go condition of reactor instrumentation is detailed. Effects of redundance and independence of circuits are evaluated. The probability of instrumentation functioning is formulated for logic systems having no common points and one common point; the formulations are then generalized to j common points. Examples are included for the particular and general cases. (M.L.S.)

**17816** (CEA-CONF-1117) CONTINUOUS MEASUREMENT OF DEFORMATION DURING IN-PILE IRRADIATION. RESULTS OBTAINED FROM RESONANT CAVITIES. Masson, M.; Millies, P.; Warlop, R. (Commissariat a l'Energie Atomique, Grenoble (France). Centre d'Etudes Nucleaires). July 24, 1968. 17p. (In French). (Pi(NT)-461-103/68; CONF-681039-2). Dep.

From Euratom Conference on Irradiation Equipment, Grenoble, France.

The dimensional behavior of structural materials or fuels exposed to radiation results from the action of various phenomena such as creep, growth, swelling, densification, cycling, Wigner effect, etc. A device was constructed to measure directly under reactor flux and continuously the dimensional variations of samples. The method is based on the use of klystrons associated with a reference cavity or with a frequency meter. The results of measurements made on the elongation of a fuel rod, the creep of stainless steel samples, and the densification of silica were reported. The results obtained agree with measurements made on the sample after irradiation. The easy operation and relatively low cost of the apparatus make it advantageous for wide application. (J.S.R.)

**17817** (CEA-CONF-1119) CENTRALIZATION OF MEASUREMENTS AND REGULATIONS OF EXPERIMENTAL EQUIPMENT IN SILOE. Guerin, M. (Commissariat a l'Energie Atomique, Grenoble (France). Centre d'Etudes Nucleaires). Aug. 7, 1968. 17p. (In French). (Pi(NT)-170-110; CONF-681039-1). Dep.

From Euratom Conference on Irradiation Equipment, Grenoble, France.

An apparatus based on a universal computer capable of greater versatility than a centralized measurement apparatus with cabled program was installed at Siloe to control the experimental devices and to centralize the data from the experiments. The two principal parts of the control system consist of a centralizer and a calculator. These are described. A monitor program makes it possible to examine the paths of an apparatus without risk of mixing with the paths of neighboring experiments. (J.S.R.)

**17818** (CEA-CONF-1157) ANALYTICAL CHAIN. Pages, A.; Delaitre, B.; Avril, M.; Moreau, R.; Hameau, P.; Labrely, J. (Commissariat a l'Energie Atomique, Saclay (France). Centre d'Etudes Nucleaires). [nd]. 3p. (In French). (CONF-680906-16). Dep.

From International Symposium on Nuclear Electronics, Versailles, France.

In order to improve the resolution of an analysis chain, a proportional amplifier, a pile-up eliminator, a linear switch, and a fast analyzer with 1 to 8 channels were studied. The essential characteristics of the proportional amplifier and the linear switch are given. These four elements assembled make it possible to obtain, with a generator peak mixed with signals from a photomultiplier, a resolution of 1/1400 at half amplitude. (J.S.R.)

**17819** (HASL-194) INVESTIGATION OF RECIRCULATION BY STRATOSPHERIC AIR SAMPLERS. Loysen, P.; Franklin, H. (New York Operations Office (AEC), N. Y. Health and Safety Lab.). Dec. 1968. 16p. Dep. CFSTI.

Possible recirculation through stratospheric air samplers was investigated to determine whether radio-nuclide concentrations required adjustment. Recirculation would reduce radionuclide concentrations, making reported values too low. The technique used to measure recirculation was detection of ethane with a combustible gas detector following discharge from a sampler exhaust. A gas detection system, developed at the Health and Safety Laboratory and tested under simulated stratospheric conditions, was used in a routine sampling flight to measure recirculation. The flight experiment conclusively showed that no recirculation occurred. Theoretical corroboration of this result was not attempted because of the complex aerodynamics involved, and the consideration that beyond the experimental testing time conditions for the promotion of recirculation would not exist. (auth)

**17820** (INR-964) AN ANALYSIS OF FAST DOUBLE–TRIPLE AND DOUBLE–MULTIPLE COINCIDENCE CIRCUITS INFLUENCED BY STATISTICAL TIME SPREADS. Kalisz, Jozef (Institute of Nuclear Research, Warsaw (Poland)). 1968. 60p. (In Polish). Dep.

Fast multiple coincidence circuits which consist of two or more double coincidence circuits connected in series are studied. With respect to the double-triple coincidence circuit, which con-

sists of two double coincidence circuits, the probability density of registration time of the first double coincidence circuit, the coincidence surface, and the coincidence curve of the whole double-triple coincidence circuit are determined analytically. The analysis is carried out with the assumption of Gaussian jitter distributions, uncorrelated, at the circuit inputs. The slope method and the point method are presented for determination of statistical parameters of the circuit including resolving time, jitter breadth, and efficiency. For the latter method the results of numerical calculations are presented in the form of tables and diagrams. A detailed comparison is given between the circuit analyzed and the classical triple coincidence circuit with respect to efficiency, resolution, random coincidence, and electronic features. The theory is next generalized for double-multifold coincidence circuits. (auth)

**17821** (KURRI-TR-8, pp 98-107) AN APPARATUS FOR DETERMINING THE MOESSBAUER EFFECT. Yishioka, Susumu (Tokyo Shibaura [Electric] Co. Ltd., Kawasaki, Kanagawa Prefecture (Japan)). (In Japanese).

An apparatus, based on the principle of velocity-sweep multiple-wave analysis, was constructed to measure the Mössbauer effect using a $^{57}Co$ source prepared by electroplating a copper plate in a solution of $CoCl_2$; iron was used as the absorber. The natural abundance of $^{57}Fe$ in iron was found to be sufficient, making it possible to use stainless steel sheets of 20 mg/cm$^2$. A NaI crystal was used as the detector; a thickness of 0.2 to 0.3 mm was found to be best for detecting 14.4-keV and 132-keV $\gamma$ radiation. A feedback system generating parabolic motion was used for modulation; it was able to operate the time-pulse-height transducer without requiring specialized equipment. The apparatus can be used for experiments to study nuclear moment, isomeric shift, parity, internal shift, impurity effects, lattice defects and pressure effects; it may be also applied for measuring the Debye temperature and the state of annealing of metals. (TTT)

**17822** (LA-4066) CALIBRATION OF A SPINNING-DISC AEROSOL GENERATOR AND TWO-STAGE AIR SAMPLERS. Partridge, Jennings E.; Ettinger, Harry J. (Los Alamos Scientific Lab., N. Mex.). Dec. 15, 1968. Contract W-7405-eng-36. 14p. Dep. CFSTI.

A spinning disc aerosol generator was calibrated using various concentrations of 80% methylene blue, 20% uranine in ethyl alcohol. Monodisperse aerosols with count median diameters ranging from 1.45 to 7.48 $\mu$m, and geometric standard deviations ranging from 1.03 to 1.10 were produced. The aerosol generator constant (K) was 4.90 ± 0.25. Two different types of two-stage samplers were calibrated using monodisperse aerosols produced by this generator. One type, using a horizontal elutriator as the first-stage size selector, agreed with the criteria defining respirable dust adopted by the British Medical Research Council. The other type, using a small cyclone as the first-stage size selector, agreed with criteria proposed at the Los Alamos Conference when operated at approximately half its recommended flow rate. Operation of this cyclone at its recommended flow rate underestimates any inhalation hazard. (auth)

**17823** (LA-4091) HIGH VOLTAGE REGENERATIVE PULSE MODULATOR. Doss, James D. (Los Alamos Scientific Lab., N. Mex.). July 1968. Contract W-7405-eng-36. 52p. Dep. CFSTI.

The design of a high voltage pulse modulator that employs positive feedback to generate output pulses of variable width is described. The modulator is intended for use as a switching device to drive the modulating anode of a five-cavity klystron. The klystron develops more than one million watts of peak power at a frequency of 805 MHz, with duty factors up to 12%. The modulating anode voltage drive requirement is approximately 80 kV with the current drain being of the order of 0.01 ampere. The total modulator current output will be approximately one ampere with most of the current flowing through a load resistor that is in parallel with the modulating anode. Pulse widths will range from 100 $\mu$sec to 1 msec. Rise and fall times are minimized to reduce operating expenses. The regenerative modulator replaces a more traditional circuit that has cost and size disadvantages. An analysis of the design of the regenerative modulator is presented. (auth)

**17824** (SC-CR-68-3547) TRANSIENT PULSE TRANSMISSION USING IMPEDANCE LOADED CYLINDRICAL ANTENNAS. Final Report. Merewether, David E. (New Mexico Univ., Albuquerque. Bureau of Engineering Research). Feb. 1968. 118p. (EE-149). Dep. CFSTI.

For Sandia Corp., Albuquerque, N. Mex.

Two aspects of the problem of pulse transmission using impedance loaded cylindrical antennas have been considered. First, an approximate solution is obtained for the current distribution on a thin cylindrical antenna driven at an arbitrary point along its length. This solution may be applied to an antenna of any length, and its simplicity makes the current distribution rapidly computable. This solution is ideal for the prediction of the transient electromagnetic field radiated when an arbitrary voltage transient is impressed across the input terminals of a long, thin, cylindrical antenna loaded with lumped impedances. Second, an antenna synthesis procedure is evolved. This synthesis procedure yields a selection of resistor pairs to be used to symmetrically load a cylindrical antenna so that the radiated electromagnetic field pulse approximates some prescribed waveshape. The length of the antenna required to obtain a useful approximation is also considered. Since a voltage step was the assumed input to the antenna, the waveshape that can be approximated is limited to fast rising, generally decaying functions of time. (auth)

**17825** (WAPD-TM-769) PROGRAMMED DENSITOMETER: AUTOMATIC RADIOGRAPH INTERPRETER. Kirk, K. D.; Wargo, E. J. (Bettis Atomic Power Lab., Pittsburgh, Pa.). Jan. 1969. Contract AT(11-1)-Gen-14. 55p. Dep. CFSTI.

An automatic radiograph interpreter, designated the programmed densitometer, has been developed to inspect radiographs of plate-type zoned nuclear reactor fuel. A photo-resistive detector is used to sense the radiographic film density; the signal is then digitized, and fed into a small digital data processor for analysis. The same processor is used to direct initial gage setup for each radiograph, to control film motion through the gage, and to print an inspection record. Over 1800 radiographs were processed through the programmed densitometer and checked manually. No radiographs indicating rejectable product were accepted, and over 97 percent of the acceptable radiographs were accepted by the densitometer. It is estimated that this acceptance level would be increased to over 99 percent by reradiographing and reinspecting those radiographs that were rejected. (auth)

**17826** CALCULATION OF SPECTRAL ION DOSE EXPOSURE RATE AND INTENSITY DISTRIBUTION OF SOFT X RAYS FROM FILTRATION DATA. Hasl, Guenther J. (Univ. of Erlangen, Ger.). Strahlentherapie, 136: 196-9(1968). (In German).

The spectrum of the exposure rate of a beryllium window tube operating at 45 kVp was computed from aluminum filtration data. From the spectral exposure rate distribution the intensity distribution was calculated. The mean value of the wavelength of the spectral exposure rate distribution was $\lambda_f$ = 1.6 Å and of the spectral intensity $\lambda_q$ = 1.03 Å. The exposure rate was measured with an total absorbing calorimeter. The calculated and measured intensity as a function of the thickness of the aluminum filters are in good agreement. (auth)

**17827** CONTRAST ENHANCEMENT AND QUANTITATION OF SCANS BY MEANS OF A HIGH-SPEED DIGITAL COMPUTER. Tauxe, W. Newlon (Mayo Clinic, Rochester, Minn.); Chaapel, Donald W.; Sprau, Allen C. pp 41-9 of Symposium on Computers and Scanning. Hidalgo, John U. (ed.). New York, Society of Nuclear Medicine, 1967.

See CONF-651210.

Computer-produced quantitative scans in digital format have been shown to lack the disadvantages of scans in which enhancement techniques have been effected in analogue form (such as color) and to offer further important advantages. As many as 20 activity gradations may be used instead of six colors. Manipulation of data can be easily accomplished. This includes: corrections for background and radioisotope decay, running statistical analyses, total organ summation and elimination of scalloping or directional unevenness of count rate. A major advantage is that of economy of both time and capital investment. Equipment beyond the pulse-height analyzer of a scanner is not essential. An on-line production of 20 high-contrast levels, with all of the contour plots herein described, can be accomplished for less than $4.00 of IBM 7040 time. (auth)

**17828** QUANTIFICATION OF SCAN RECORDS. Harris, C. C. (Oak Ridge National Lab., Tenn.). pp 50-6 of Symposium on Computers and Scanning. Hidalgo, John U. (ed.). New York, Society of Nuclear Medicine, 1967.

See CONF-651210.

The information obtained by use of moving-detector and stationary scanners is considerably more quantitative than popularly believed over the last decade. The clinical usefulness of scan information can be greatly enhanced by proper storage of these data for subsequent retrieval and manipulation. The use of computers provides a means of storage, retrieval and manipulation. Simple methods are also possible and very useful. The intelligent use of information requires the maximum possible use of the quantitative aspect and no means, however simple, should be overlooked. (auth)

**17829** COMPUTERS: WHAT THEY ARE AND WHAT THEY DO. Nettleton, Wilson J. Jr. (Tulane Univ., New Orleans).

pp 5-10 of Symposium on Computers and Scanning. Hidalgo, John U. (ed.). New York, Society of Nuclear Medicine, 1967.
See CONF-651210.

The types of input and output data received in and extracted from computers are described. The various components of computers are examined. A brief analysis of programming is also presented. (B.G.D.)

**17830** USES OF COMPUTERS. Hidalgo, John U. (Tulane Univ., New Orleans). pp 11-20 of Symposium on Computers and Scanning. Hidalgo, John U. (ed.). New York, Society of Nuclear Medicine, 1967.
See CONF-651210.

Several applications of computer techniques have been described wherein the computer has been used for a variety of tasks, ranging from extended multiplication tables to experimental design and complex data analysis. It seems logical that the computer will not be able to solve all problems, but it is quite certain that the intelligent use of this device will be of great assistance in a very wide variety of applications. The key to these blessings lies in skill of the user in devising ways and means of developing useful applications. (auth)

**17831** DETECTOR FOR MEASURING VOID IN A REACTOR CORE. Yusa, Hideo (to Hitachi Ltd.). Japanese Patent 1968-27098. Nov. 9, 1968. Filed June 19, 1965.

The method proposed has the following advantages: high resistance against heat and pressure; and compact structure, capable of insertion in narrow places. A core wire is connected to a lead wire cladded with a heat-resistant material. A metal film in the form of a tube is used as the shield to the core wire where the tube surrounds the wire; the space between the tube and the wire is filled with a ceramic material. The top end, i.e. the electrode of the core wire, and the ceramic at this position are attached by a suitable means. An iron piece is attached at the other end of the shield tube and a stainless-steel pipe, containing the lead wire axially, is joined to the shield tube (filled with the ceramic material), through this metal piece. (NSA of Japan)

**17832** DETECTOR FOR MEASURING VOID IN A REACTOR CORE. Yusa, Hideo (to Hitachi Ltd.). Japanese Patent 1968-27096. Nov. 9, 1968. Filed Feb. 19, 1965.

The method proposed can give a compact void detector, capable of insertion in narrow places. A core wire is run through a tube, and an electrode is attached to its bottom end, just outside the bottom end of the tube; this bottom end of the tube is sealed with an insulating material. The inner tube, with a core wire and an electrode, is enclosed in an outer tube, so that water runs through the inner and the outer tubes. The electrode-to-core wire is a positive electrode, and the outer tube is a negative electrode. The signal of a void between the two tubes is taken by means of the change of impedance. (NSA of Japan)

**17833** DIAGNOSTIC X-RAY APPARATUS USING TELEVISION SYSTEM. Nagai, Katumi; Sasaki, Ken'ichi (Tokyo Shibaura Electric Co.). Toshiba Rebyu, 24: 138-41(Feb. 1969). (In Japanese).

A remote-controlled diagnostic x-ray tv unit for universal use is described. The most distinctive features of this apparatus are that the remote controlled 90/90 tilting table is provided with a fully automatic full-size spot-film device which is able to stock six cassettes in advance and the spot-film radiography can be controlled automatically by a direct phototimer system. (auth) (NSA of Japan)

**17834** DETECTOR FOR MEASURING VOID IN A REACTOR CORE. Yusa, Hideo (to Hitachi Ltd.). Japanese Patent 1968-29104. Nov. 29, 1968. Filed Jan. 23, 1965.

The void-measuring detector proposed is compact, capable of insertion in narrow places. The signal of a void is taken by means of the change of impedance. A core wire runs through a tube; an electrode is attached to the end of the wire, just outside the (same direction) end of the tube. The end of the tube is sealed with a metallized alumina; the penetration through the alumina is also metallized. The tube with the core wire is filled with an insulating material. (NSA of Japan)

**17835** PROGRAM AND TABLES FOR CALCULATING THE STATISTICAL PARAMETERS OF THE TRIPLE COINCIDENCE CIRCUIT. Ruszkowska, A. (Computing Center, Warsaw); Kalisz, J. Acta Phys. Pol., 34: 995-1007(Dec. 1968).

A computer program is described for calculating the resolving time, jitter breadth and efficiency of the triple coincidence circuit on the basis of the point method. A simple case is considered, where the resolving time and jitter breadth is the same with respect to all inputs of the circuit. The use of the Owen function T(h,a) in the computation is explained. Exact tables calculated for the point parameter k = 0.01, 0.1, 0.25 are given. (auth)

**17836** GRAZING-INCIDENCE TELESCOPES FOR X-RAY ASTRONOMY. Giacconi, R.; Reidy, W. P.; Vaiana, G. S.; Van Speybroeck, L. P.; Zehnpfennig, T. F. (American Science and Engineering, Cambridge, Mass.). Space Sci. Rev., 9: 3-57 (Feb. 1969).

The progress made over the past several years in developing grazing-incidence imaging x-ray optics is reviewed. Mirrors, detection systems, and dispersion techniques are discussed and experimental results are given. The application of two telescope systems to a number of experimental observations in x-ray astronomy is discussed. (auth)

**17837** ANALOG COMPUTER FOR CALCULATION OF SECOND MOMENTS IN NMR. Gibson, A. A. V.; Raab, R. E. (Univ. Of Natal, Pietermaritzburg, South Africa). Rev. Sci. Instrum., 40: 410-13(Mar. 1969).

A special purpose analog computer is described for calculating the second moment of the NMR absorption spectrum drawn out by a wide-line spectrometer with an integrating phase-sensitive detector (PSD). An experimental check on $NH_4Cl$ yielded a mean second moment within 1% of a previous value, and a standard error over 50 observations of 2%. The integrating PSD enabled these spectra to be recorded over 100-sec sweeps with a signal-to-noise ratio comparable to that obtained using conventional techniques with sweep times at least an order of magnitude longer. (auth)

**17838** MOLECULAR-BEAM TIME-OF-FLIGHT SPECTROSCOPY. Alcalay, Jack A.; Knuth, Eldon L. (Univ. of California, Los Angeles). Rev. Sci. Instrum., 40: 438-47(Mar. 1969).

A method for determining the speed distribution and density of a molecular beam from time-domain measurements of propagated beam perturbations is examined. Algebraic relations between the moments of the measured time-of-flight signal, of the speed-distribution function, of the modulator gate function, and of the dynamic function of the detector and its electronics are derived. By extracting a sufficient number of moments, one can characterize any speed-distribution function of any desired accuracy. For use in applications, moments and recursion relations of a general class of speed-distribution functions and moments of some typical gate functions are developed. Sufficient conditions for approximating a rectangular gate function by an impulsive gate function are presented. An application to time-of-flight measurements in an arc-heated supersonic molecular beam illustrates the use of the general method and emphasizes the need to consider the characteristic time of the gate function and the dynamic response functions of the detector and its electronics when interpreting time-of-flight signals. (auth)

**17839** LUMPED ELEMENT LINE GENERATORS TO PRODUCE PULSED SINUSOIDAL OSCILLATIONS OF VERY LARGE POWER. Lietti, A. (Laboratoire de Recherches, Lausanne, Switzerland). Rev. Sci. Instrum., 40: 473-82(Mar. 1969).

After reviewing the present state of knowledge concerning the technique of making high power sinusoidal pulses, an improved kind of line generator is proposed. An analysis of wave propagation in a periodic structure together with the numerical solution of the network differential equations shows that it is possible to utilize the recurrent triggering system (hitherto applied only to homogeneous lines) with lumped element lines. A method for designing such lines is presented. Numerical tables are included and some selected examples are discussed. The theory agrees with an experiment made with a prototype line. The construction of a 720 MW, 3 MHz installation for use in plasma physics experiments is already underway. This large power is achieved by paralleling a number of lumped element line generators. (auth)

**17840** CONSIDERATIONS IN THE PACKAGING OF ANALOG–DIGITAL CONVERTERS. Cohn, Charles Erwin (Argonne National Lab., Ill.). Rev. Sci. Instrum., 40: 512-13(Mar. 1969).

The type of analog-digital converter (ADC) used for pulse height analysis with digital computers is commonly packaged with the ADC proper and the channel count scaler in the same enclosure. It was found that such a configuration is suboptimal, and much is to be gained by having the ADC and the scaler in separate enclosures. (auth)

**17841** TRIANGULAR SAWTOOTH SWEEP FOR NMR WITH PROVISION FOR MANUAL OPERATION OF TIME AVERAGING. Wisnosky, Dennis E. (Carnegie-Mellon Univ., Pittsburgh). Rev. Sci. Instrum., 40: 499-500(Mar. 1969).

The design of an instrument with the combined features required to sweep linearly both an NMR magnet current regulator and a voltage-controlled crystal oscillator is presented. The main features are the choice of a repetitive triangle or sawtooth or completely manual operation with a trigger available for time averaging in auto modes. (W.H.K.)

**17842** IMPROVEMENT OF SPECTRAL BASELINE STABILITY FOR A TIME-OF-FLIGHT MASS SPECTROMETER OPERATED AT ELEVATED PRESSURES. Miller, C. D.; Tiernan, T. O.; Futrell, J. H. (Aerospace Research Labs., Wright-Patterson Air Force Base, Ohio). Rev. Sci. Instrum., 40: 503-4 (Mar. 1969).

Design modifications of the grid assembly of a time-of-flight mass spectrometer for operation at source pressures up to 1 Torr are described to improve the baseline stability. (W.H.K.)

**17843** DETERMINATION OF THRESHOLD FAILURE LEVELS OF SEMICONDUCTOR DIODES AND TRANSISTORS DUE TO PULSE VOLTAGES. Wunsch, D. C.; Bell, R. R. (Braddock, Dunn and McDonald, Inc., El Paso, Texas). IEEE (Inst. Elec. Electron. Eng.), Trans. Nucl. Sci., NS-15: No. 6, 244-59(Dec. 1968).

From Annual Conference on Nuclear and Space Radiation Effects, Missoula, Mont. See CONF-680706.

Theoretical predictions of circuit failure in an electromagnetic pulse (EMP) environment require a knowledge of failure levels for each component of the circuit due to surge voltages or currents. For most circuits, the semiconductor devices are the weakest elements with respect to such failure. Results of an extensive experimental program to determine pulse power failure levels of semiconductor junctions are presented. Approximately 80 different types of silicon diodes and transistors were studied with variations in junction areas from $10^{-4}$ to $10^{-1}$ cm$^2$ and with widely varying junction geometries. Power levels of up to two kilowatts, with time durations of 0.1 to 20 microseconds, were applied to semiconductor junctions in both forward and reverse polarity modes. A semi-empirical formula, based on experimental data and on a simple thermal failure model is given. From the formula one can make order-of-magnitude estimates of the failure level as a function of pulse length for many silicon diodes or transistors whose junction area is known. (auth)

**17844** MILLION CHANNEL PULSE HEIGHT ANALYSER THROUGH PSEUDO-RANDOM DIGITAL TRANSFORMATION. Soucek, B.; Bonacic, V.; Culjat, K. (Inst. Ruder Boskovic, Zagreb). Nucl. Instrum. Methods, 66: 202-12(Dec. 15, 1968).

In all nuclear spectroscopy experiments data are collected in the form as they come from the source. It would be very difficult and expensive to analyse such data in million-channel resolution. A new technique is developed in which data from experiments are first digitally transformed into a new form and then analyzed. Digital transformation is applied on-line to each event (descriptor). Passing through a transformation box, each descriptor produces a pseudo-random address into which it is stored. Transformation comprehends a scattered multidimensional physical spectrum into a minimal space, enabling high speed, on-line, multidimensional, million-channel spectrometry. The computer system, which operates as a mega-channel, transformation mode analyser is described. Experiments with a real and computer simulated spectra show a very short dead time and high efficiency of the memory utilization of the system. Transformation can be realized by simple hardware between ADC's and computer, or as a part of a computer interrupt routine. Both solutions are described. (auth)

**17845** SOLAR WIND SIMULATOR OF ADVANCED DESIGN WITH EXTENDED OPERATIONAL CAPABILITIES. Meckel, Ben B.; Lebduska, Robert L. (Physics Tech. Labs., Inc., La Mesa, Calif.). pp 164-9 of IES/AIAA/ASTM Third Space Simulation Conference. Mt. Prospect, Ill., Institute of Environmental Sciences, 1968.

From 3rd Space Simulation Conference, Seattle, Wash. See CONF-680947.

The design and performance of large diameter mass analyzed ion beams for laboratory studies of solar plasma wind are presented. The system consists of an ion source, a mass separator, a beam mass analyzer, and a Faraday cup for ion energy and density distribution measurements. (W.H.K.)

**17846** MAGNETIC FIELD FLUCTUATIONS AND RESONANCE CONDITION STABILIZATION IN NMDR SPECTROMETERS. Suegis, A.; Alla, M. Izv. Akad. Nauk Est. SSR, Fiz. Mat., 17: 426-32(1968).

Proton high-resolution nuclear magnetic double resonance (NMDR) spectrometers require the highest possible degree of stabilization of the ratio $\omega/H_0$. During the period of scanning of the whole spectrum the permissible long-term instability is only a small fraction of the line width. Moreover, even magnetic field fluctuations of a quite short duration must be avoided. In case of monoresonance only fluctuations within the bandwidth of the recorder are of significance. In case of double resonance the perturbing rf field $H_2$ of much greater amplitude also affects the spectral line to be observed. This is due to the noise sideband produced by field fluctuations near the frequency difference between the two rf fields. The direct influence of strong rf field $H_2$ on the line to be observed via noise sideband can give considerable output within the bandwidth of the recorder and seriously disturb the investigation of a given double resonance effect. Some results of research on the frequency response and noise characteristics of the magnet, flux stabilizer, and spin stabilizers within the frequency range of 0.01–1000 Hz are presented. (auth)

**17847** FOCUSING OF A TIME-OF-FLIGHT DIFFRACTOMETER FOR STRUCTURE ANALYSIS. THE EXPERIMENTAL CHECK. Holas, A.; Holas, J.; Maliszewski, E.; Sedlakova, L. (Joint Inst. for Nuclear Research, Dubna, USSR). Nucl. Instrum. Methods, 69: 173-80(Mar. 1969).

An experimental check of focusing the neutron time-of-flight diffractometer for crystal structure analysis is presented. The obtained results proved the formulae for focusing. The intensity of the focused diffractometer was increased by an order of magnitude as compared with the previous diffractometer (with collimators) of the same resolution. (auth)

**17848** HYPERFINE STATE SELECTION OF HYDROGEN ATOMS BY LONGITUDINAL PERIODIC-FIELD MAGNETIC LENSES. Checkrahamatoula (Faculte des Sciences, Orsay, France). Nucl. Instrum. Methods, 69: 45-55(Mar. 1969).

Optical properties of a longitudinal periodic-field magnetic lens associated with a source of hydrogen atoms are studied. With the help of hydrogen atom dynamics, it is shown that the lens is equivalent to a (transverse field) six-pole magnet and that it could possibly be used for state selection of atoms in different devices (hydrogen maser, polarized ion sources). Using this equivalence, optical elements of the lens are calculated and their numerical values compared with those given by a precise determination of atomic trajectories. Particular attention is given to the problem of depolarization of atoms caused by successive crossings of the weak field regions in the lens. It is shown there that the depolarization rate is practically negligible. (auth)

**17849** SUMMING UNIT WITH VISUAL READ OUT FOR USE WITH A MULTICHANNEL PULSE HEIGHT ANALYSER. Roberts, P. B.; Campbell, J. I. (Radiological Protection Service, Belmont, Eng.). Nucl. Instrum. Methods, 69: 131-5(Mar. 1969).

A summing unit for use with a multichannel pulse height analyser or memory unit is described. The stored data are decoded and accumulated in a series-parallel counter having visual indicators on which the total is displayed. (auth)

**17850** AN APPROACH TO HIGH WATTAGE CALORIMETRY. O'Hara, F. A.; Jordan, K. C.; Birden, J. H. (Mound Lab., Miamisburg, Ohio). Contract AT(33-1)-GEN-53. Nucl. Instrum. Methods, 69: 35-40(Mar. 1969).

For a number of years isothermal, water-bath calorimeters have been used at Mound Laboratory to assay radioactive samples with thermal power from ½ to 100 W. The theory of operation for a calorimeter of this general type is presented and two specific systems are described. The basic design of such a system has been extended to provide a water-bath calorimeter capable of measuring thermal outputs up to about 1500 W. Difficulties with such a system are discussed and possible solutions advanced. The precision probable error at present is better than 0.2%. Performances of various water-bath calorimeter systems are compared. (auth)

**17851** DESCRIPTION AND CHARACTERISTICS OF A RAPID RESPONSE MASS SPECTROMETER FOR RESIDUAL GAS ANALYSIS. Evans, S.; Collins, R. (Edwards High Vacuum Ltd., Crawley, Eng.). Vide, 23: 416-24(Nov.-Dec. 1968). (In French).

Residual analysis has become increasingly important in vacuum research and two instruments are described which are suitable for this purpose. For total pressures below $10^{-9}$ torr in static systems a 180° mass spectrometer with a mass range of 2–105 and a resolution of approximately 40 has been developed. For total pressures below $10^{-9}$ torr and for investigations of dynamic vacuum systems a small 60° sector field mass spectrometer of high sensitivity and with fast scanning facilities was designed for residual gas analysis and similar applications. The instrument was constructed of stainless steel, with a demountable, nude ion source, and was bakeable to 350°C. Using a particle multiplier, the minimum detectable partial pressure was about $10^{-14}$ torr at a scanning rate a few seconds per mass peak, and $10^{-10}$ torr at less than one millisecond per mass peak. For fast scanning applications, space charge control of the electron beam was desirable, to eliminate emission fluctuations arising from thermal inertia associated with the more conventional temperature control. Experimental results of the application of this instrument to residual gas analysis in vacuum systems are presented. (auth)

**17852** PROCEEDINGS OF THE THIRTEENTH NATIONAL ISA AEROSPACE INSTRUMENTATION SYMPOSIUM, SAN DIEGO, CALIFORNIA, JUNE 13–16, 1967. ISA (Instrum. Soc. Amer.), Proc., Nat. Aerosp. Instrum. Symp., 13th, San Diego, 1967, 1-502 (1967). (CONF-670658).

Separate abstracts were prepared for 2 of the 46 papers presented. The remaining 44 papers were not within the scope of NSA. (W.H.K.)

*For abstracts of individual papers see: 17781 and 18515.*

## Radiation Effects on Instruments and Instrument Components

*Refer also to abstracts 18731–18736, and 18747.*

**17853** (AD-672812) EFFECTS OF RADIATION ON SEMICONDUCTOR MATERIALS AND DEVICES. Final Report, January 1–December 31, 1967. Wilson, D. K.; Mitchell, J. P.; Cuthbert, J. D.; Lee, H. S. (Western Electric Co., Inc., New York). Apr. 30, 1968. Contract F19628-67-C-0147. 190p. (AFCRL-68-0250). CFSTI.

Results of investigations on the effects of nuclear radiation on semiconductor materials, device surface layers, and devices are discussed. (auth) (USGRDR)

**17854** (COO-1624-14) RECOMBINATION STATISTICS FOR THE NEUTRON-INDUCED BASE CURRENT COMPONENT. Chow, Ming-chwan (Missouri Univ., Rolla). 1968. Contract AT(11-1)-1624. 142p. Dep. CFSTI.

Thesis.

A derivation of the recombination statistical model for the neutron-induced base current component is presented. The derivation is based on the assumptions: the current equation for the induced current component developed by Goben is valid; the Shockley-Read-Hall statistics for holes and electrons are applicable; and the recombination statistics derived by Sah, Noyce, and Shockley, for sites in the bulk space-charge region are valid. Several examples are presented to emphasize accuracy of this derived model for predictions. It is shown that the recombination statistics which depend on the diffusion potential, the junction voltage, the activation energy, and the capture cross-sections for holes and electrons. Temperature dependence is involved explicitly in the statistics model. Examples are presented to illustrate the utility of such a recombination statistical model in predicting the base current for p-n junction transistors with considerable accuracy. (W.H.K.)

**17855** (COO-1624-15) RADIATION AND ANNEALING CHARACTERISTICS IN NEUTRON BOMBARDED TRANSISTORS OPERATED IN THE INVERSE CONFIGURATION. Su, Lo-soun (Missouri Univ., Rolla). 1968. Contract AT(11-1)-1624. 98p. Dep. CFSTI.

Thesis.

When operating a silicon planar epitaxial transistor in the inverse configuration the bulk space-charge volume of the new emitter-base junction is increased by a factor of 26.5 times that of the normal emitter-base junction. The carrier concentration in the new emitter is decreased by five orders of magnitude from that of the normal emitter, thus making it easier to investigate the effects of neutron radiation on the space-charge region and at the surface. Experiments using biasing of the new emitter-base junction during neutron radiation to change the depletion layer width were performed. Surface effects in the form of an inversion layer adjacent to the emitter-base junction were observed. These surface effects cause the base current to increase by a factor of 5 to 10 in the low emitter-base voltage region and the emitter-base junction capacitance to increase by a factor of approximately 2 at a fluence level of $2 \times 10^{14}$nvt. These surface effects were found to significantly anneal at room temperature. A decrease in the diffusion potential of the emitter-base junction was predicted on theoretical grounds and experimentally observed after irradiation. The diffusion potential increased after isochronal annealing but did not return to its pre-irradiated value. For the annealing studies, pairs of devices with nearly identical characteristics (matched within 10 percent) were used with one device of each pair used for isothermal annealing and the other device of each pair used for isochronal annealing. No solid conclusions concerning the annealing rate of defects in the bulk space-charge region can be drawn because of the apparent discrepancies between the isothermal and isochronal annealing data. The unannealed fraction of defects in the neutral base region was found to increase in the temperature range from 50° to 100°C and was attributed to an increase in the concentration of A-centers (oxygen-complexes). The annealing rates of defects both in the space-charge region and in the neutral base region were enhanced by the externally applied reverse voltage over temperature range from 150°C to 180°C, while the annealing rate of defects in the p-type neutral base region was retarded by the minority carrier injection above 50°C. (auth)

**17856** (COO-1624-20) NUCLEAR RADIATION EFFECTS ON SILICON p-n JUNCTIONS. Technical Progress Report. Goben, Charles A. (Missouri School of Mines and Metallurgy, Rolla). Feb. 1, 1969. Contract AT(11-1)-1624. 43p. Dep. CFSTI.

A set of recombination statistics for the neutron-induced base current component in p-n junction semiconductor devices has been created from a theoretical basis and has been checked against experimental data and found to predict the change in the base current quite well over the range where the neutron-induced current component dominates p-n junction device behavior. Work has begun on developing a model for analyzing and predicting the behavior of p-n junction semiconductor transistors with knowledge only of the basic device parameters, the applied voltages or currents at the metallic contacts, and the neutron fluence. A large increase in bulk recombination at moderate to high injection levels has been theoretically predicted and experimentally confirmed. Models for the base recombination change have been constructed and checked against experimental evidence. Further work is in progress in this area. Studies of p-n junction devices operated in the inverse configuration have been made and have contributed to the understanding of the introduction rate of the neutron-induced current component. Additionally, an interesting surface effect was found. Studies of the neutron-induced changes of the collector junction parameters are under way, and an anomalous effect indicating recombination (rather than generation, which would be expected) in the collector junction has been observed. The field dependences of the neutron-induced defects and their effect on the damage introduction rate is under investigation. The size, shape, and orientation of defect clusters in a p-n junction depletion layer is being investigated with the aid of a Scanning Electron Microscope. The mobility of radiation-induced defects under the influence of an electric field is being investigated via specially constructed p-n junction devices. The effects of neutron radiation on the high-frequency parameters of p-n junction semiconductor devices is being studied via scattering parameter measurements. A quasi-tunneling model is under consideration to determine if this model will correctly predict the observed changes induced by neutron bombardment at low and intermediate current levels. (auth)

**17857** (N-68-31622) PROTON-INDUCED DAMAGE TO SILICON SOLAR CELL ASSEMBLIES: A STATE-OF-THE-ART SURVEY. Quarterly Report. Barrett, M. J.; Stroud, R. H. (Exotech, Inc., Washington, D. C.). July 10, 1968. Contracts NAS7-100; JPL-952246. 35p. (NASA-CR-95997; QR-1). CFSTI.

For Jet Propulsion Lab., Pasadena, Calif.

The literature concerning proton-induced radiation damage to silicon solar cells and their coverslides is collected and reviewed. A summary of the state-of-the-art is presented, in which it is observed that the localized damage in the cell depends on the proton energy at the point being considered. Hence, it may be nonuniform across the thickness of the cell. Equations are available to allow computation of the effect of this damage on the electrical characteristics and are discussed. (auth) (STAR)

**17858** INFLUENCE OF GAMMA RAYS ON SOME PARAMETERS OF TRANSISTORS AND DIODES. Djakov, T.; Kortenski, T.; Ivanov, S.; Antonov, N. God. Viss. Tehn. Uc. Zavedenija, Fizika, 3: No. 1, 39-50(1967). (In Slavic).

The changes in some parameters of different types of transistors and diodes, made in Bulgaria, were investigated under γ-ray irradiation. The following conclusions were drawn: (1) γ-rays lead to a change in the basic parameters of transistors: (a) the values of $U_{B0}$, $h_{21E}$, $U_{KBmax}$, $\alpha$ and $f_\alpha$ decrease; (b) the values of $U_{ksat}$, $T_{KB0}$ and $T_{B0}$ increase, (2) up to a dose of $10^5$R and power of the dose of $5 \times 10^4$R/h no practical effects are obtained, (3) up to the dose of $0.5 \times 10^5$R the output values of the parameters are restored in the course of time after the irradiation being stopped, (4) the low frequency transistors and diodes undergo greater changes in parameters due to the irradiation, and (5) the changes in the parameters for doses up to $10^7$R are in the limits of temperature changes, permissible for the working temperature range of the germanium devices. (auth) (Abstr. of Bulg. Sci. Lit.)

**17859** DEGRADATION OF THE TIME CHARACTERISTICS OF SURFACE BARRIER DETECTORS WITH FISSION FRAGMENT DOSE. Mulas, P.; Haines, E. L. (California Inst. of Tech., Pasadena). Rev. Sci. Instrum., 40: 507-9(Mar. 1969).

A time of flight technique was used to map the differential energy losses of fission fragments in thin carbon films as a

function of their mass and initial energy. A calibration procedure without the carbon films was followed to identify and describe effects other than the slowing of the fragments by those films. Through this procedure it was observed that a degradation of the time characteristics of the fragment pulses occurred even at low doses where the charge collection characteristics of the detector were not yet affected. (auth)

**17860** ANNUAL CONFERENCE ON NUCLEAR AND SPACE RADIATION EFFECTS, UNIVERSITY OF MONTANA, MISSOULA, MONTANA, JULY 15–18, 1968. Holmes-Siedle, Andrew G. (ed.). IEEE (Inst. Elec. Electron. Eng.), Trans. Nucl. Sci., NS-15: No. 6, 1-352(Dec. 1968). (CONF-680706).

Separate abstracts were prepared for the 42 papers presented. (W.H.K.)

*For abstracts of individual papers see: 17759, 17791, 17792, 17809, 17843, 17861–17889, 17994, 18731–18736, and 19360.*

**17861** RECOVERY RATE AND CAPACITANCE MEASUREMENTS ON IRRADIATED LITHIUM-CONTAINING SOLAR CELLS. Faith, T. J.; Brucker, G. J.; Holmes-Siedle, A. G.; Neadle, R. S. (RCA Astro-Electronics Div., Princeton, N. J.). Contracts NAS5-10239; JPL 952249. IEEE (Inst. Elec. Electron. Eng.), Trans. Nucl. Sci., NS-15: No. 6, 61-8(Dec. 1968).

From Annual Conference on Nuclear and Space Radiation Effects, Missoula, Mont. See CONF-680706.

Room temperature recovery kinetics of lithium-containing p/n silicon diodes and solar-cells were experimentally investigated after irradiation by 1 MeV electrons to fluences of $10^{13}$ and $10^{14}$ e/cm$^2$. The current physical model for the recovery process involves the diffusion of a lithium donor ion to a radiation-induced vacancy-impurity defect with negative charge and high hole-capture cross section, and the complexing of the lithium donor with this defect to form a new defect with zero charge and low hole-capture cross section. The recovery rate thus depends on the lithium ion density, the lithium-ion diffusion constant, and the defect density. Direct measurements of the density profile of lithium ions in the base region near the junction were performed on 12 diodes. Using a capacitive technique with some novel features, the effective diffusion constant for lithium ions near the junction was measured on the same diodes. Further useful information was obtained by relating these properties to the rapid, room temperature recovery of minority-carrier diffusion length which is observed in these devices after irradiation. (auth)

**17862** DEFECT CLUSTERS IN ELECTRON-IRRADIATED SILICON. Wilsey, Neal D.; Statler, Richard L.; Faraday, Bruce J. (Naval Research Lab., Washington, D. C.). IEEE (Inst. Elec. Electron. Eng.), Trans. Nucl. Sci., NS-15: No. 6, 55-60 (Dec. 1968).

From Annual Conference on Nuclear and Space Radiation Effects, Missoula, Mont. See CONF-680706.

Calculations of the formation of disordered regions in silicon due to irradiation by high energy (15 to 45 MeV) electrons indicate that a sufficient concentration of defect clusters is produced to affect the electrical properties of the material. Isochronal annealing of room temperature radiation-induced degradation in the short-circuit current of silicon solar cells and in the minority carrier lifetime of the p-type base region is studied up to 500°C. The existence of a low temperature (50 to 200°C) annealing stage is shown to be independent of dopant and oxygen impurity concentration. It is inferred that this stage, which is similar to those observed in fast neutron- and in proton-irradiated silicon, is characteristic of cluster formation. (auth)

**17863** CAPACITANCE RECOVERY IN NEUTRON-IRRADIATED SILICON DIODES BY MAJORITY AND MINORITY CARRIER TRAPPING. Wilson, D. K. (Bell Telephone Labs., Inc., Whippany, N. J.). IEEE (Inst. Elec. Electron. Eng.), Trans. Nucl. Sci., NS-15: No. 6, 77-83(Dec. 1968).

From Annual Conference on Nuclear and Space Radiation Effects, Missoula, Mont. See CONF-680706.

Majority and minority carrier trapping was studied in neutron-irradiated silicon diodes by transient junction capacitance recovery as well as by capacitance-versus-frequency and pulsed field effect techniques. After exposure to damaging radiation, trapping results in a transient time dependence of depletion layer width which may determine the survivability of depletion layer devices in a radiation environment. Majority carrier traps were found in n-type neutron-irradiated silicon of $E_c - 0.36$ eV and in p-type silicon at $E_v + 0.30$ eV. The capture cross sections for both types of traps are of the order of $10^{-15}$ cm$^2$. (auth)

**17864** RADIATION AND ANNEALING CHARACTERISTICS OF NEUTRON BOMBARDED SILICON TRANSISTORS. Su, L. S.; Gassner, G. E.; Goben, C. A. (Univ. of Missouri, Rolla). Contract AT(11-1)-1624. IEEE (Inst. Elec. Electron. Eng.), Trans. Nucl. Sci., NS-15: No. 6, 95-107(Dec. 1968).

From Annual Conference on Nuclear and Space Radiation Effects, Missoula, Mont. See CONF-680706.

Operating a silicon planar epitaxial transistor in the inverse configuration allows one to demonstrate clearly the importance of the neutron-induced base current component and its degradation of the emitter efficiency, and, because of the much larger depletion layer, to compute a volume dependent damage constant applicable to all silicon p-n junctions. The importance of minimizing the absolute change versus relative change in radiation hardening studies is clearly illustrated. Surface effects were found to be significant for transistors mounted in gas-filled cans. The diffusion potential was predicted on theoretical grounds to vary with neutron fluence, and the theory was experimentally confirmed. Isochronal and isothermal annealing data were obtained for the inverse configuration and from these data it is concluded that the neutron-induced defect centers are field dependent. (auth)

**17865** THE EFFECTS OF NEUTRON RADIATION ON SECOND BREAKDOWN AND THERMAL BEHAVIOR OF SILICON TRANSISTORS. Reich, Bernard; Hakim, Edward B.; Hunter, Edwin T. (Army Electronics Command, Fort Monmouth, N. J.). IEEE (Inst. Elec. Electron. Eng.), Trans. Nucl. Sci., NS-15: No. 6, 108-13(Dec. 1968).

From Annual Conference on Nuclear and Space Radiation Effects, Missoula, Mont. See CONF-680706.

A method of measuring and the subsequent analysis of this data has indicated that the thermal time constant of silicon diffused transistors decreases with increasing neutron dosage. Empirically, it was noted that thermal time constant degradation constants can be assigned to all devices examined. For the silicon planar devices studied, degradation constants varied from $2.6 \times 10^{-13}$ cm$^2$/neut for the radiation resistant devices, to $1.4 \times 10^{-12}$ cm$^2$/neut for other devices. By examining previous data for single diffused transistors the thermal time constant degradation factor was $2 \times 10^{-11}$ cm$^2$/neut. It is concluded that the thermal time constant, which is related to second breakdown, effectively degrades upon exposure to neutron radiation, thereby decreasing the safe operating area of the device. However, the extent of degradation per dose may be predictable. (auth)

**17866** RADIATION EFFECTS ON SILICON AVALANCHE (IMPATT) DIODES. Wilson, D. K.; Lee, H. S.; Noffke, H. (Bell Telephone Labs., Whippany, N. J.). Contract AT19(628)-67C-0147. IEEE (Inst. Elec. Electron. Eng.), Trans. Nucl. Sci., NS-15: No. 6, 114-25(Dec. 1968).

From Annual Conference on Nuclear and Space Radiation Effects, Missoula, Mont. See CONF-680706.

The effects of fast neutrons with fluences up to $10^{16}$ n/cm$^2$ on both dc and microwave characteristics of nearly abrupt X-band avalanche diodes were studied. Good forward dc characteristics were observed up to $2 \times 10^{15}$ n/cm$^2$. At higher doses, the forward characteristics are degraded by the formation of a thin intrinsic layer at the metallurgical PN junction. The thickness of the intrinsic layer and its effects on device behavior could be reduced by reducing the depth of the diffused junction. At neutron fluences exceeding $4 \times 10^{15}$ n/cm$^2$, the avalanche breakdown voltage has a negative temperature dependence which results in a marked degradation in device reliability. Microwave oscillator characteristics — including oscillation threshold, power output, frequency, efficiency, and FM and AM noise — were virtually unchanged up to $10^{15}$ n/cm$^2$. At neutron fluences greater than $10^{15}$ n/cm$^2$, the oscillation threshold decreased and power output increased significantly (by 2 to 6 dB). The greatest improvements occurred for the lowest-output power devices. These results suggest the use of nuclear radiation to tailor the defect concentrations and the field profiles of avalanche diodes to achieve optimal structures. (auth)

**17867** NEUTRON RADIATION EFFECTS ON MOS FETS: THEORY AND EXPERIMENT. Witteles, A. A. (General Precision Systems Inc., Little Falls, N. J.). IEEE (Inst. Elec. Electron. Eng.), Trans. Nucl. Sci., NS-15: No. 6, 126-32(Dec. 1968).

From Annual Conference on Nuclear and Space Radiation Effects, Missoula, Mont. See CONF-680706.

The effects of a pure neutron environment on Metal-Oxide-Semiconductor Field Effect Transistors (MOS-FET) is studied. A model for neutron-produced ionization in the oxide layer is presented. The energy partition between atomic displacement and electronic ionization processes in the nuclear scattering interaction is calculated and compared to the Lindhard model. It is shown that the neutron ionization causes a positive charge buildup in the oxide similar to a gamma ionization charge buildup.

It is also shown that fast neutrons produce significant ionization energy which can become the major cause for ionization damage in a mixed neutron-gamma environment such as a nuclear blast. Specific experimental results are given for commercial and experimental MOS-FETS. The experimental technique used in achieving an almost pure neutron environment is described. Finally, an ionization dose equivalence for fast neutrons in $SiO_2$ is given and compared to experimental values. This relation should prove useful in future studies of ionization damage in $SiO_2$ subjected to a neutron-gamma environment. (auth)

**17868** STATISTICAL MODELING OF SEMICONDUCTOR DEVICES FOR THE TREE ENVIRONMENT. Messenger, George C.; Steele, Earl L. (AUTONETICS, Anaheim, Calif.). IEEE (Inst. Elec. Electron. Eng.), Trans. Nucl. Sci., NS-15: No. 6, 133-9(Dec. 1968).

From Annual Conference on Nuclear and Space Radiation Effects, Missoula, Mont. See CONF-680706.

The transistor model used in the Autonetics Transient Radiation Analysis by Computer (TRAC) code is discussed. Particular emphasis is placed on the simulation of radiation-induced photocurrent in the p-n junctions. The photocurrent generator is first derived for a single junction. The result is then extended to the transistor model by appropriately combining two junctions which interact. The interaction is accomplished by including a current transport factor at each junction, as in the Ebers and Moll formulation. The photocurrents are then examined in terms of defining equations which lead to the criterion for measuring the photocurrent parameters which, in turn, are related to the conventionally defined primary photocurrents in the devices. A statistical analysis for treating the change in current gain factor with neutrons is also presented. Histograms of actual device measurements are shown to permit the determination of the damage constants. The resulting damage constant for silicon devices is given for neutron radiation. The primary photocurrent generator model is also evaluated in terms of statistical measurements on silicon devices. (auth)

**17869** TECHNIQUES FOR INVESTIGATING INTEGRATED CIRCUIT DIELECTRIC ISOLATION MEDIA. Frankovsky, F.; Protschka, H.; Zappert, F. (IBM Electronics Systems Center, Owego, N. Y.). Contract F19628-67-0306. IEEE (Inst. Elec. Electron. Eng.), Trans. Nucl. Sci., NS-15: No. 6, 140-53(Dec. 1968).

From Annual Conference on Nuclear and Space Radiation Effects, Missoula, Mont. See CONF-680706.

Two different techniques for investigating the dielectric isolation of integrated circuits manufactured by this method of isolation are discussed. The study concentrates on the two radiation effects of induced transient conductivity and charge storage in silicon dioxide. The first technique is theoretical involving a mathematical model which considers some of the physical processes in silicon dioxide under irradiation. A system of partial differential equations is derived from a consideration of some of the possible mechanisms and carrier kinetics occurring in the oxide as a result of radiation. A sub-routine was then written for an existing computer program (SCEPTRE) which was used to numerically solve the continuity equations describing the model. Primary outputs of the computer program are the transient current density, total charge in the oxide, and the surface charge induced in the silicon by the charge in the oxide which then allows one to also calculate the induced charge in the gate electrode. In addition, available as outputs are the local electric field, local charge density, and the instantaneous density of electron and hole charge carriers throughout the dielectric. The other technique is an empirical method of nondestructively determining an existing nominal electric field in unirradiated, irradiated and then annealed silicon–silicon dioxide–polycrystalline silicon (SOS) structures. This method of investigation is based on the quadratic electro optical Kerr effect. From results obtained by applying external bias voltage on these SOS-structures it was concluded that the nominal internal electric field in the oxide is directed toward the polycrystalline silicon region. Positive charges created and stored in the dielectric may then be located near single crystal silicon–oxide interface for these SOS-structures. (auth)

**17870** RECOMBINATION STATISTICS FOR NEUTRON BOMBARDED SILICON TRANSISTORS. Chow, M. C.; Azarewicz, J. L.; Goben, C. A. (Univ. of Missouri, Rolla). Contract AT(11-1)-1624. IEEE (Inst. Elec. Electron. Eng.), Trans. Nucl. Sci., NS-15: 88-94(Dec. 1968).

From Annual Conference on Nuclear and Space Radiation Effects, Missoula, Mont. See CONF-680706.

A recombination statistical model for the neutron-induced base current is presented. The derivation is based on the following: (1) the current equation for the induced current component developed previously; (2) the Shockley-Read-Hall statistics for holes and electrons; and (3) the recombination statistics derived by Sah, Noyce and Shockley for sites in the bulk space-charge region. The recombination statistics model depends on the diffusion potential, the junction voltage, the activation energy, temperature, and the ratio of capture cross-sections for holes and electrons. The utility of such a recombination statistical model is illustrated by using measured parameters to predict the neutron-induced base current for p-n junction transistors and by comparing the results with measured base currents. Further, the temperature variation of the reciprocal slope term is calculated from the model and found to agree well with experiment. (auth)

**17871** RAPID ANNEALING IN SILICON TRANSISTORS. Binder, D.; Butcher, D. T.; Crepps, J. R.; Hammer, E. L. (Hughes Aircraft Co., Fullerton, Calif.). Contract F29601-68-C-0007). IEEE(Inst. Elec. Electron. Eng.), Trans. Nucl. Sci., NS-15: No. 6, 84-7(Dec. 1968).

From Annual Conference on Nuclear and Space Radiation Effects, Missoula, Mont. See CONF-680706.

Rapid annealing data after a pulse of reactor neutrons for seven NPN planar transistors at room temperature and the 2N1613 at various temperatures down to dry ice were interpreted in terms of the motion of a single type of mobile defect. An equation was derived for the recombination of the defect with fixed defects in a spherical cluster and the subsequent diffusion of the defect outside the cluster. This treatment leads to an identification of two stages of annealing, with a transition time between stages at room temperature of a few milliseconds. The variation in the transition time with temperature for the 2N1613 is used to derive an activation energy of (0.28 ± 0.02) eV, which agrees, within error, with that for the vacancy in p-type silicon. A calculation of the cluster radius is in reasonable agreement with one-half the primary recoil range. (auth)

**17872** RADIATION HARDNESS OF OVONIC DEVICES. Ovshinsky, Stanford R.; Evans, E. J.; Nelson, D. L.; Fritzsche, H. (Energy Conversion Devices, Inc., Troy, Mich.). IEEE (Inst. Elec. Electron. Eng.), Trans. Nucl. Sci., NS-15: No. 6, 311-21(Dec. 1968).

From Annual Conference on Nuclear and Space Radiation Effects, Missoula, Mont. See CONF-680706.

Ovonic threshold switches were exposed to pulses of flash x-rays to levels of $1.8 \times 10^{11}$ rads/sec and to fast neutron fluences of as high as nvt = $1.2 \times 10^{17}$ n/cm$^2$. The switching devices continued to function during the transient of the x-ray flash and experienced no permanent damage or change of their electrical parameters in excess of the resolution of the experimental testing procedure which was about ±100% in the case of the neutron exposure. (auth)

**17873** RADIATION EFFECTS UPON GALLIUM ARSENIDE DEVICES. Schnurr, R. H.; Southward, H. D. (Univ. of New Mexico, Albuquerque). Contract F29601-67-C-0051. IEEE (Inst. Elec. Electron. Eng.), Trans. Nucl. Sci., NS-15: No. 6, 306-10(Dec. 1968).

From Annual Conference on Nuclear and Space Radiation Effects, Missoula, Mont. See CONF-680706.

The behavior of gallium arsenide Gunn oscillators, transistors, Schottky barrier diodes and optoelectronic pulse amplifier, were investigated in a flash x-ray environment. The damaging effects of fast neutrons from a pulsed reactor were also observed. When possible, the resultant data were compared with available data for similar silicon devices. (auth)

**17874** PREDICTING COMBINED NEUTRON DEGRADATION AND GAMMA INDUCED EFFECTS ON A CLOSED LOOP SYSTEM. Kleiner, C. T.; Tanke, J. M.; Romano, M. J. (North American Rockwell Corp., Anaheim, Calif.). IEEE (Inst. Elec. Electron. Eng.), Trans. Nucl. Sci., NS-15: No. 6, 295-305(Dec. 1968).

From Annual Conference on Nuclear and Space Radiation Effects, Missoula, Mont. See CONF-680706.

A technique for modeling open loop or closed loop systems in either functional block representation and/or multiple circuit configurations utilizing actual piece-parts data is described. Computer programs have been developed to represent systems as functional blocks or transfer functions. The SECURE program incorporates a multiplicity of detailed circuits and transfer functions which provides a more complete prediction of system response based on piece-part models. The program and piece-part models contain the capability of simulating and therefore predicting system response to an ionizing and displacement radiation. Comparison between SECURE results and a linear controls system analysis program demonstrates the close agreement between simulation results. By the use of superposition the

simulation was extended to include the radiation effects of an operational amplifier. The response of the amplifier had been predicted using the TRAC computer code. The radiation response of a closed loop system is compared with results obtained when detailed circuitry is simulated by use of the SECURE program. The system used as an illustrative example is a closed loop single axis inertial platform. As a part of the prediction, the SECURE code is used as a design aid in selecting circuit configurations and modifying circuit design. (auth)

**17875** SQUARE-LOOP MAGNETIC CORE MODEL FOR COMPUTER-AIDED CIRCUIT TRANSIENT ANALYSIS. Nitzen, David (Stanford Research Inst., Menlo Park, Calif.). Contract NAS7-100. IEEE (Inst. Elec. Electron. Eng.), Trans. Nucl. Sci., NS-15: No. 6, 285-94(Dec. 1968).

From Annual Conference on Nuclear and Space Radiation Effects, Missoula, Mont. See CONF-680706.

A square-loop magnetic core model used by an automated circuit-analysis computer program is described. The core parameters may be measured or derived from a manufacturer catalog. The model has been incorporated into the automated computer-program TRAC (Transient Radiation Analysis by Computer), which was subsequently applied to transient analyses of several magnetic circuits. Machine-computed voltage and current waveforms agree satisfactorily with experimental oscillograms. (auth)

**17876** MODELS FOR PREDICTING TRANSIENT RADIATION RESPONSES IN MICROCIRCUITS. Bowman, W. C.; Beezhold, W.; Johnston, A. H. (Boeing Co., Seattle). IEEE (Inst. Elec. Electron. Eng.), Trans. Nucl. Sci., NS-15: No. 6, 279-84 (Dec. 1968).

From Annual Conference on Nuclear and Space Radiation Effects, Missoula, Mont. See CONF-680706.

Modeling studies conducted on oxide- and junction-isolated microcircuits for dose rates from $10^7$ to $10^{12}$ rads (Si)/sec are described. The charge-control model is used for the oxide-isolated transistors, and the junction-isolated transistor model used is essentially a two transistor equivalent with the redundant junction equation eliminated. (W.H.K.)

**17877** LUMPED-MODEL ANALYSIS OF MICROCIRCUIT VULNERABILITY. Raymond, J. P.; Chang, W. W.; Budris, R. E. (Northrop Corporate Labs., Hawthorne, Calif.). Contract DA-AB07-67-C-0419. IEEE (Inst. Elec. Electron. Eng.), Trans. Nucl. Sci., NS-15: No. 6, 271-8(Dec. 1968).

From Annual Conference on Nuclear and Space Radiation Effects, Missoula, Mont. See CONF-680706.

Ionizing radiation effects in simple monolithic microcircuits have been predicted from the microcircuit geometry, electrical measurements, and basic semiconductor parameters. Using the lumped-model technique, the mathematical model of the microcircuit is derived directly from the electronic characteristics and boundary values of each bulk semiconductor region. Basic parameter values of the circuit model are obtained by correlating calculated results to the experimental data. Ionizing radiation effects are included as the radiation carrier generation per unit volume. Since the ionizing radiation effect is included in terms of the bulk semiconductor parameters, the radiation-inclusive lumped model is a straightforward extension of the electrical model. Results are presented for the large-signal electrical and radiation-induced response of junction-isolated and dielectric-isolated DTL gates and the small-signal electrical and radiation-induced response of a junction-isolated differential amplifier. Calculation of the electrical and radiation-induced responses was enabled with the use of SCEPTRE and ECAP circuit analysis computer codes, for the gate and amplifier analyses, respectively. Use of lumped models in the classical circuit element computer codes was accomplished by deriving the analogous R-C-I networks corresponding to the lumped-models. Representation of the electrical performance and radiation-induced response of the micro-circuits was generally very good. The major source of error in the analysis is in the representation of the diffused resistor photo-response, which in this case, did not include the effects of interleg coupling and conductivity modulation. (auth)

**17878** ANALYSIS OF THERMAL PERFORMANCE OF ELECTRICAL INSTRUMENTS IN A NUCLEAR ENVIRONMENT. Blinn, H. O. (Westinghouse Astronuclear Lab., Pittsburgh). IEEE (Inst. Elec. Electron. Eng.), Trans. Nucl. Sci., NS-15: No. 6, 267-70(Dec. 1968).

From Annual Conference on Nuclear and Space Radiation Effects, Missoula, Mont. See CONF-680706.

A method and results of a thermal analysis typical of the approach taken to develop electrical transducers for the NERVA reactor program are described. The analytical techniques developed have been successfully applied to electrical transducers and mechanical components for use in a nuclear environment where heat is generated internally in the device by gamma radiation. These techniques have proven to be an important part of the overall radiation effects program directed toward obtaining reliable instrumentation for the NERVA program. (auth)

**17879** IMPROVED RADIATION STORAGE TIME PREDICTIONS BY A NEW APPROACH TO INVERTED TRANSISTOR CHARACTERIZATION. Unwin, A. M.; Rosenberg, C. (Boeing Co., Seattle). Contract AF29(601)-7083. IEEE (Inst. Elec. Electron. Eng.), Trans. Nucl. Sci., NS-15: No. 6, 260-6(Dec. 1968).

From Annual Conference on Nuclear and Space Radiation Effects, Missoula, Mont. See CONF-680706.

This paper describes and assesses a technique for obtaining those inverted transistor parameters which are required for an accurate prediction of electrical and radiation storage times. The technique, which is based on electrical storage time measurements, was applied to six transistors manufactured by three methods: diffused silicon, epitaxial silicon, and alloyed germanium. The response of these transistors was measured over a range of exposure rates ($3 \times 10^7$ to $6 \times 10^{10}$ R/sec) and saturation collector currents (2 to 40 ma). Accurate computer predictions of the radiation responses were obtained and several interesting results were inferred from the study. It was found that the primary photocurrent is insensitive to the amount of forward bias on the collector junction. Another inference was the propriety of ignoring apparent superlinearities in the dependence of photocurrent on rate. A third, and particularly interesting result, was that there appear to be three types of dependence of radiation storage time on the logarithm of dose rate: sublinear, linear, and superlinear according to the degree of saturation being light, moderate, and heavy, respectively. This reconciles the discrepancy between the different theoretical rate dependences developed by Carr and by Gage. An additional result was the apparent insensitivity of the results to certain known approximations of the model used in the computer program. (auth)

**17880** RADIATION EFFECTS ON NERVA INSTRUMENTATION. Gilles, W. P. (Aerojet-General Corp., Sacramento, Calif.). IEEE (Inst. Elec. Electron. Eng.), Trans. Nucl. Sci., NS-15: No. 6, 239-43(Dec. 1968).

From Annual Conference on Nuclear and Space Radiation Effects, Missoula, Mont. See CONF-680706.

The NERVA program presented the instrumentation engineer with difficult radiation-effects problems. Gamma fluxes reach $10^9$ rads (C)/hr and neutron fluences approach $10^{18}$ n/cm$^2$ (E > 1.0 MeV). These problems and some of their solutions and test results are presented. (auth)

**17881** EFFECT OF TEMPERATURE ON MICROCIRCUIT RADIATION RESPONSE. Johnston, Allan H.; Bowman, William C. (Boeing Co., Seattle). IEEE (Inst. Elec. Electron. Eng.), Trans. Nucl. Sci., NS-15: No. 6, 232-8(Dec. 1968).

From Annual Conference on Nuclear and Space Radiation Effects, Missoula, Mont. See CONF-680706.

The effect of temperature on the primary photocurrent of the base-collector and collector-substrate junctions of isolated transistors from three types of microcircuits was investigated over the temperature range −50 to 125°C. Only small changes in base-collector primary photocurrent were observed, whereas collector-substrate primary photocurrent increased by a factor of three to five with decreasing temperature. The temperature dependence of the transient response of two microcircuits near the failure threshold is analyzed and shown to depend on the temperature dependence of primary photocurrent and transistor electrical parameters. (auth)

**17882** LOW DOSE IONIZATION-INDUCED FAILURES IN ACTIVE BIPOLAR TRANSISTORS. Measel, P. R.; Brown, R. R. (Boeing Co., Seattle). IEEE (Inst. Elec. Electron. Eng.), Trans. Nucl. Sci., NS-15: No. 6, 224-31(Dec. 1968).

From Annual Conference on Nuclear and Space Radiation Effects, Missoula, Mont. See CONF-680706.

Gain degradation under different conditions of applied voltage and injection current during low dose gamma irradiation by a cobalt-60 source was examined for the 2N1613, 2N2102 and 2N3799 type transistors. For transistors biased during irradiation, the gain degradation was greater for higher collector-base voltages applied during irradiation, and the gain degradation was less for higher emitter current levels during irradiation. However, the dependence of gain degradation on current during irradiation was small for the 2N1613, and the dependence of gain degradation on voltage during irradiation was small for the 2N3799. Several methods of data presentation are used. The presentation of the gain degradation in terms of percent remaining gain is found to facilitate

intercomparison of results and to provide a format which is readily applicable to design problems. The method of normalization of the data to give the percent remaining gain is analyzed and is demonstrated to be justified. When expressed as a percentage, the degradation of low gain transistor types is as significant as the high gain transistor type at the same total dose with bias present during irradiation. (auth)

**17883** A PREDICTION AND SELECTION SYSTEM FOR RADIATION EFFECTS IN PLANAR TRANSISTORS. Poch, W.; Holmes-Siedle, A. G. (RCA Astro-Electronics Div., Princeton, N. J.). Contracts NAS5-9034; NAS5-10306. IEEE (Inst. Elec. Electron. Eng.), Trans. Nucl. Sci., NS-15: No. 6, 213-23 (Dec. 1968).

From Annual Conference on Nuclear and Space Radiation Effects, Missoula, Mont. See CONF-680706.

Radiation tests on a wide range of planar silicon bipolar transistors under high-energy radiation indicate that the degradation of gain due to the ionizing component of radiation is due to a surface effect namely, an increase in the surface recombination velocity near the emitter-base junction. This effect is dominant in many real-life operating environments encountered by space electronic systems, and can produce quite serious losses of gain. A practical prediction technique for the surface effect is described and applied to a wide range of space-approved bipolar transistor devices. Specifications of the expected levels of surface damage, devised from such data, have only rarely been exceeded in subsequent sampling tests. The prediction technique requires data from a cobalt-60 gamma-ray test of 10 to 20 samples of each device type. Progress in using this prediction technique is reported. (auth)

**17884** RECOVERY OF GAMMA DOSE MILITARY SPECIFICATION FAILURES DURING LOW AND HIGH POWER LIFE TESTING OF SILICON TRANSISTORS. Brown, R. R.; Horne, W. E.; Hamilton, A. E. (Boeing Co., Seattle). IEEE (Inst. Elec. Electron. Eng.), Trans. Nucl. Sci., NS-15: No. 6, 205-12 (Dec. 1968).

From Annual Conference on Nuclear and Space Radiation Effects, Missoula, Mont. See CONF-680706.

A statistical investigation to determine recovery of and long term reliability of silicon transistors degraded by total gamma dose is presented. (auth)

**17885** SCALING LAWS FOR IONIZATION EFFECTS IN INSULATORS. van Lint, V. A. J.; Harrity, J. W.; Flanagan, T. M. (Gulf General Atomic Inc., San Diego, Calif.). Contracts DA28-043 AMC-02446(E); DAAG-39-67-C-0028. IEEE (Inst. Elec. Electron. Eng.), Trans. Nucl. Sci., NS-15: No. 6, 194-204(Dec. 1968).

From Annual Conference on Nuclear and Space Radiation Effects, Missoula, Mont. See CONF-680706.

A new formulation is presented for radiation-induced conductivity in insulators which takes cognizance of the fact that the ionization is formed along particle tracks rather than being uniformly distributed throughout the material. This leads to a linear dependence of conductivity on dose rate with, however, a possibility of an additional dependence on dose for high doses. Data are presented demonstrating this linear dependence. (auth)

**17886** LASER INTERFEROMETRIC DETERMINATION OF THE DYNAMIC RESPONSE OF SOLIDS. Oswald, R. B. Jr.; Schallhorn, D. R.; Eisen, H. A. (Harry Diamond Labs., Washington, D. C.). IEEE (Inst. Elec. Electron. Eng.), Trans. Nucl. Sci., NS-15: No. 6, 187-93(Dec. 1968).

From Annual Conference on Nuclear and Space Radiation Effects, Missoula, Mont. See CONF-680706.

Measurements of the dynamic response of a solid induced by charged particle interaction are presented. The measurements were made using a laser interferometric technique to determine the free surface motion of silicon and germanium exposed to a pulsed electron beam. The results show that the free surface displacement and velocity can be determined in detail. The measured displacement and velocity histories are directly related to the energy spectrum of the incident electron beam and proportional to the electron fluence. The measurements are compared with the motion predicted by a thermoelastic calculation using known material properties. The difference between the predicted and measured response is discussed with respect to the coupling between the absorbed energy and the acoustic phonons. (auth)

**17887** INVESTIGATION OF RADIATION DAMAGE IN MOSFETS USING BIAS-TEMPERATURE TREATMENTS. Danchenko, Vitaly (Goddard Space Flight Center, Greenbelt, Md.); Brashears, Sidney S. IEEE (Inst. Elec. Electron. Eng.), Trans. Nucl. Sci., NS-15: No. 6, 182-6(Dec. 1968).

From Annual Conference on Nuclear and Space Radiation Effects, Missoula, Mont. See CONF-680706.

Radiation damage in thermally grown p-channel enhancement mode MOS devices irradiated with 1.5 MeV electrons at various doses and gate potentials was investigated by applying bias-temperature (B-T) treatments. It was found that at negative and small positive gate biases applied during irradiation, electrons are trapped in weakly bound states in the oxide. These trapped electrons may readily be removed from the oxide by B-T treatment. The ratio of electrons trapped in the oxide to the radiation-induced net positive charge has a maximum at about −3V bombardment bias. This region of gate bias also corresponds to the minimum of radiation damage commonly observed in this type of device. At zero bombardment bias a saturation of shallow electron trapping is observed at a dose of $3-6 \times 10^{13}$ e/cm$^2$. (auth)

**17888** RADIATION EFFECTS IN MODIFIED OXIDE INSULATORS IN MOS STRUCTURES. Perkins, C. W. (Hughes Aircraft Co., Fullerton, Calif.); Aubuchon, K. G.; Dill, H. G. Contract NOnr-4837(00). IEEE (Inst. Elec. Electron. Eng.), Trans. Nucl. Sci., NS-15: No. 6, 176-81(Dec. 1968).

From Annual Conference on Nuclear and Space Radiation Effects, Missoula, Mont. See CONF-680706.

Radiation-induced permanent shifts in gate threshold voltages were measured for MOS structures with variations in the structure of the oxide insulator and compared to the shifts for pure unaltered silicon dioxide. The variations include phosphosilicate glass coating of the oxide surface, aluminum ion-implantation into the surface, and a silicon nitride layer over the oxide. In all cases, the modified form became relatively insensitive to radiation under positive gate voltages and extremely sensitive to radiation under negative gate voltages in contra-distinction to the pure oxide, which is much less sensitive at negative than at positive gate voltages. Only the nitride modification led eventually to hardened devices for both polarities. Analysis leads to the conclusion that the models for positive space charge buildup in the oxide must include photoemission of electrons into the oxide from either the silicon or the metal gate, depending on the gate voltage, and also the possibility of mobile holes. (auth)

**17889** ELECTRON IRRADIATION OF NPN BIPOLAR TRANSISTORS WITH SILICON NITRIDE PASSIVATION. Stanley, Alan G. (Massachusetts Inst. of Tech., Lexington). IEEE (Inst. Elec. Electron. Eng.), Trans. Nucl. Sci., NS-15: No. 6, 168-75(Dec. 1968).

From Annual Conference on Nuclear and Space Radiation Effects, Missoula, Mont. See CONF-680706.

The effect of silicon nitride passivation on the performance of bipolar transistors under ionizing radiation was investigated. Three groups of silicon planar epitaxial npn transistors with silicon nitride, silicon dioxide and composite silicon dioxide-silicon nitride insulating layers were subjected to irradiation by 20 keV and by 1.5 MeV electrons. The base and collector currents were measured as a function of base-emitter voltage. The results show that silicon nitride and silicon dioxide passivated transistors possess identical properties, after irradiation by low energy electrons to saturation, even though the preirradiation d.c. gain of the standard devices was much greater. Irradiation by 1.5 MeV electrons caused channel formation in all three groups. (auth)

**17890** RADIATION-RESISTANT MOS DEVICES. Lindmayer, Joseph (Comsat Labs., Washington, D. C.); Noble, Wendell P. Jr. IEEE (Inst. Elec. Electron Eng.) Trans. Electron. Devices, ED-15: 637-40(Sept. 1968).

Effects of $\gamma$ radiation on MOS (metal oxide semiconductor) devices are studied with particular attention to their dependence on the details of fabrication. A model for the mechanism of radiation-induced changes is based on these results, from which it is apparent that radiation hardness depends basically on the ionization of the minor bonds within the oxide. A MOS structure can be created that remains operational for $\gamma$-ray doses above $10^7$ rad. It is shown that the radiation resistance varies with gate oxidation and the metals employed. Two metals were used in the experiments: Al and Cr. The relation between radiation and thermal stability is also discussed, and it is shown that there is some connection between the two as long as the same basic technology is used. However, combinations that result in thermal stability may still show a low radiation resistance. Irradiation generates positive-charge centers in the oxide and these centers are related to minor bonds in the oxide. In this respect, the oxide-metal interactions were considered. The greatest radiation resistance will be found for p-enhancement devices and for certain n-depletion structures. Measurements show results for p-enhancement units with radiation resistance 100 times greater than previously reported figures, both for MOS and bipolar transistors. (BBB)

**17891** INSTABILITY IN THE REVERSE I-V CHARACTERISTICS OF SILICON p-n JUNCTIONS INDUCED BY LOW-ENERGY

ELECTRON IRRADIATION. Lee, W. I. (Kyungpook National Univ., Taegu, Korea). J. Korean Phys. Soc. 1: 81-9(Oct. 1968).

The behavior of the reverse I-V characteristics of silicon p-n junctions under the bombardment of low energy (≤20 keV) electron beams was investigated. The results suggest the introduction of generation-recombination centers in the space-charge region of the junctions resulting in softness in the reverse I-V characteristics. Some carriers are believed to be trapped causing a localized strong electric field, which together with the applied field, leads to the Zener breakdown mechanism. This effect is more pronounced when the beam energy is low. As the beam energy increases, the field emission component decreases while the generation current component increases. For energies of 16 to 20 keV, the excess reverse current is almost entirely due to the generation component. The slow recovery of the I-V characteristics at room temperature suggests the disappearance of generation-recombination centers associated with the electron bombardment. However, the nature of the centers remains open to further investigation. (auth)

**17892** CURRENT OSCILLATIONS IN Si p-i-n DEVICES AFTER IRRADIATION WITH 1-MeV ELECTRONS. Streetman, B. G.; Holonyak, N. Jr.; Krone, H. V.; Compton, W. Dale (Univ. of Illinois, Urbana). Appl. Phys. Lett., 14: 63-5(Jan. 15, 1969).

Current oscillations similar to those previously reported in various semiconductors with impurity-induced traps have been observed in Si irradiated at 0°C with 1-MeV electrons. The oscillations are altered by annealing of the devices at temperatures below 0°C. (auth)

# LIFE SCIENCES

## Biochemistry, Physiology, and Molecular Biology

*Refer also to abstracts 17397, 17779, 17995, 18014, 18079, 18081, 18084, 18100, 18108, 18111, 18113, 18117, 18119, and 18143.*

**17893** (AEC-tr-7030, pp 119-30) THREE- AND FOUR-COMPONENT MODELS OF CESIUM METABOLISM IN RATS AND HUMAN BEINGS. Krasnoshchekova, G. P.; Likhtarev, I. A.; Ushakova, A. P. Translation of report A-AC-82/G/L-1251.

A method of obtaining constants that characterize the processes of cesium exchange in warm-blooded animals is described. The entire metabolic system is represented as a set of compartments joined by a number of transfer links. Diagrams and equations are presented for describing three and four compartment models of $^{137}Cs$ exchange. Consideration of the compartments may be of interest in protecting the human organism against radiation: for example, slowing down the process of cesium transition from the ionic state to the organically bound state, or accelerating the removal of the latter from intracellular fluid into extracellular fluid. The models might also be used for medical diagnosis of liver and other pathologies. (H.L.W.)

**17894** (CONF-670503–, pp 191-7) CONCENTRATION OF SODIUM BY FRESHWATER TURTLES. Dunson, William A. (Pennsylvania State Univ., University Park. Dept. of Biology).

Food has been thought to be the primary route of electrolyte uptake in aquatic turtles. Recent investigations of ion fluxes in freshwater turtles (Trionyx, and Pseudemys) indicate there can be a significant amount of Na uptake from the environment by means of active transport. Measurements of influx in the intact animal and studies of membranes in vitro in an Ussing cell indicated the transport was localized in the membranes of the oral and the cloacal regions. Na uptake is an important feature of the adaptation of these animals to fresh water, particularly in areas with cold winters. Hibernating turtles in the laboratory or in nature lose large amounts of Na which must be replaced upon emergence by feeding and by active uptake of ions. The mechanism of uptake also appears to be of general use at other times of the year, especially when food intake is reduced. Freshwater turtles have developed an Na uptake mechanism very similar to ion transport systems found in fish and amphibians. In light of this, turtles should be studied further to determine their importance in concentration of dissolved radioisotopes. (auth)

**17895** (CONF-670503–, pp 198-220) ACCUMULATION AND DISTRIBUTION OF $^{54}Mn$ AND $^{65}Zn$ IN FRESHWATER CLAMS. Harrison, Florence L. (California Univ., Livermore. Lawrence Radiation Lab.).

The accumulation and distribution of $^{54}Mn$ and $^{65}Zn$ in the freshwater clam Anodonta nuttalliana Lea was followed for 147 days under conditions where the concentrations of Mn and Zn in the water remained constant. The amounts of the radionuclides in the clam bodies increased essentially linearly during the uptake period. The concentrations of $^{54}Mn$ and $^{65}Zn$ showed considerable variation from tissue to tissue, but generally the concentrations within a given tissue were equivalent. Steady-state conditions of accumulation and loss were reached after about 100 days in the digestive tract, gonad, muscles and excretory organs. However, in the calcareous tissue, mantle and gills, steady-state conditions were not reached in the 147 days. The rates of accumulation were found to be dependent on the concentration of the stable element in the water, the temperature and size of the animals. The rates of loss of the stable element from the clam body were slow—the large long-lived pool of Mn having a half life of about 1300 days, that of Zn of 650. Measurements of specific activities indicated that in all parts of the body a large fraction of the Mn and Zn was in pools with which the radionuclides did not exchange. In Anodonta nuttalliana Lea, the main storage site in the body of Mn and Zn as well as Ca was in 1- to 2-micron granules in the calcareous tissue. (auth)

**17896** (CONF-670503–, pp 355-62) INFLUENCE OF ENVIRONMENTAL FACTORS ON THE CONCENTRATIONS OF $^{65}Zn$ BY AN EXPERIMENTAL COMMUNITY. Duke, T.; Willis, J.; Price, T.; Fischler, K. (Bureau of Commercial Fisheries, Beaufort, N. C Radiobiological Lab.).

Differences in salinity, temperature, pH, and zinc in the water significantly affected the concentration of $^{65}Zn$ from seawater by a community of oysters, clams, mud crabs, and scallops and their sediment substrate. A factorial analysis of variance showed no interactions among the environmental factors. High salinity and zinc concentration suppressed the concentration of $^{65}Zn$ in animals and sediment, whereas high temperature and pH had the opposite effect. Temporal variation in concentration factors for control animals and sediment was significant during the experiment. Such variation must be considered when reporting concentration factors for radionuclides in marine organisms. (auth)

**17897** (CONF-670503–, pp 389-98) COMPARISON BETWEEN THE UPTAKE OF RADIOACTIVE AND STABLE ZINC BY A MARINE UNICELLULAR ALGA. Bernhard, M.; Zattera, A. (Comitato Nazionale per l'Energia Nucleare, La Spezia (Italy). Laboratorio per lo Studio Della Contaminazione Radioattiva del Mare).

The uptake of $^{65}Zn$ and stable zinc by a marine unicellular alga (Phaeodactylum tricornutum) and by a chelating resin (Chelex-100) was studied during a certain time interval in batch cultures. In all experiments the distribution pattern of $^{65}Zn$ and stable zinc between the particulate matter (algae or chelating resin) and the natural and artificial seawater medium was different. When the $^{65}Zn$ was added as ionic zinc, proportionately much more radioactive zinc was taken up than stable zinc. Adding the $^{65}Zn$ as Zn-EDTA-complex, however, to a batch containing seawater and Chelex the stable zinc was initially taken up at a higher rate than was $^{65}Zn$. These preliminary results do not explain the difference in the distribution of radioactive and stable zinc, but the data do show that the uptake rate of the stable isotope does not necessarily follow the uptake rate of the radioactive isotope if the two are present in different physical-chemical states. This possibility must be taken into account in tracer studies and in predictions of the distribution of radioisotopes in the environment based on the specific isotope content approach. (auth)

**17898** (CONF-670503–, pp 399-411) METABOLISM OF $^{65}Zn$ IN EUPHAUSIIDS. Fowler, Scott W.; Small, Lawrence F. (Oregon State Univ., Corvallis. Dept. of Oceanography); Dean John Mark (Battelle-Northwest, Richland, Wash. Pacific Northwest Lab.).

In order to help understand the biological role of zinc in marine food-chain organisms, we studied uptake and retention of $^{65}Zn$ by the pelagic crustaceans Euphausia pacifica and Thysanoessa spinifera. Experiments were performed at three temperatures (5, 10, and 15 C) and two concentrations of radiozinc (10 and 25 $\mu$Ci/l). Weight-specific uptake and elimination of $^{65}Zn$ by dead (formalin-preserved) animals and by live animals (before molting) were statistically similar over all temperatures and $^{65}Zn$ concentrations tested. Molted exoskeletons averaged 41% of total live body activity. Dissection of euphausiids into exoskeleton, eyes, and muscle and gut combined showed that the largest fraction of radiozinc was always associated with the exoskeleton. The second largest fraction was associated with muscle and gut, with a smaller fraction in the eyes and body fluid. Autoradiographs showed that $^{65}Zn$ mainly was located on the exoskeleton and between the muscle fibers, not intra-myofibrillar. Weight-specific activity varied inversely with weight, suggesting a surface area phenomenon for uptake and loss. An inverse linear relationship between animal weight and percentage of total activity in exoskeletons, with a concomitant positive linear relationship between animal weight and percentage of total activity in muscle and gut, also suggested that uptake and elimination of $^{65}Zn$ were largely a function of surface area. The $Q_{10}$ for $^{65}Zn$ uptake (5 to 15 C) was almost twice that for oxygen consumption. The relationships between $^{65}Zn$ uptake and dry weight, and between oxygen consumption and dry weight, varied by an order of magnitude. We conclude from the above evidence that $^{65}Zn$ uptake from water is neither directly nor indirectly related to euphausiid metabolism. Some of the factors that make radiozinc uptake a poor index of metabolism (particularly molting) are responsible for making euphausiids potentially important in the cycling of radioactivity from "hot" pools in the sea. (auth)

**17899** (CONF-670503–, pp 420-30) TRANSFER OF $^{65}Zn$ AND $^{51}Cr$ THROUGH AN ESTUARINE FOOD CHAIN. Baptist, John P.; Lewis, Curtis W. (Bureau of Commercial Fisheries, Beaufort, N. C. Radiobiological Lab.).

The transfer of assimilated and unassimilated $^{65}Zn$ and $^{51}Cr$ was followed through an experimental food chain that included phytoplankton, brine shrimp, post-larval fish, and mummichog. Both radionuclides were successively transferred through each level to the fourth trophic level, and the concentrations generally declined up the food chain. Assimilated concentrations of $^{65}Zn$ were higher than those of $^{51}Cr$ in all trophic levels. Experimental data were used to calculate theoretical maximum concentrations.

Comparison of the results from the food chain with results of experiments on uptake from seawater indicated that the food chain was generally the more efficient pathway for uptake of $^{65}Zn$ and $^{51}Cr$ by all trophic levels except the second. (auth)

**17900** (CONF-670503–, pp 440-9) RADIOISOTOPE MEASUREMENTS OF THE VISCERA OF PACIFIC SALMON. Kujala, Norman F.; Larsen, I. Lauren; Osterberg, Charles L. (Oregon State Univ., Corvallis. Dept. of Oceanography).

Pacific salmon, Oncorhynchus spp., concentrate certain gamma-emitting radionuclides ($^{65}Zn$, $^{54}Mn$, $^{40}K$, and $^{137}Cs$) in their viscera. In some cases the pattern of concentration of radionuclides seems related to the position of the freshwater plume of the Columbia River, a well-known source of $^{65}Zn$ in the northeast Pacific Ocean. Fishes whose migration paths were far south of the river had more $^{65}Zn$, but less $^{54}Mn$. In south-eastern Alaskan waters there was a distinct difference in relative abundance of $^{65}Zn$ and $^{54}Mn$ in salmon. Manganese-54 was the dominant isotope in salmon of northern Alaskan waters and $^{65}Zn$ was more prominent in the spectra of fishes from Canadian and contingent United States waters. The Columbia River plume undoubtedly accounted for this increase in $^{65}Zn$. Concentrations of radionuclides differ with species and stocks of salmon. The chinook and coho salmon, which feed more on small fishes than the sockeye, accumulated the highest concentrations of $^{65}Zn$, $^{54}Mn$, and $^{137}Cs$. On the other hand, the sockeye, feeding on a lower tropic level, had low radioactivity, with $^{54}Mn$ the dominant radionuclide, some $^{65}Zn$, and no $^{137}Cs$. The chum and pink salmon examined most nearly resembled the sockeye in radioactivity. Ocean food habits and migratory pathways both appear relevant to the levels of artificially produced gamma-emitters in the viscera of salmon. (auth)

**17901** (CONF-670503–, pp 450-61) THE EFFECT OF TEMPERATURE, SEDIMENT, AND FEEDING ON THE BEHAVIOR OF FOUR RADIONUCLIDES IN A MARINE BENTHIC AMPHIPOD. Cross, Ford A.; Dean, John M.; Osterberg, Charles L. (Oregon State Univ., Corvallis. Dept. of Oceanography).

Laboratory studies were conducted to determine the effects of temperature, feeding, and presence of sediments on the behavior of $^{65}Zn$ in a new species of gammarid amphipod (Anonyx sp.). This benthic amphipod was captured in 80 meters of water off the Oregon coast. In the feeding experiments, $^{144}Ce$, $^{46}Sc$, and $^{51}Cr$ were used in addition to $^{65}Zn$. Accumulation and elimination rates of $^{65}Zn$ were temperature dependent, although the effect appeared to be minimal within this organism's seasonal temperature range. Individual differences in $^{65}Zn$ accumulation rates for amphipods of similar size had a mean standard deviation range of 14 to 19%. Elimination rates of $^{65}Zn$ were increased in the presence of sediment and were significantly greater in feeding than in nonfeeding amphipods. Anonyx which fed on adult Artemia labeled simultaneously with $^{65}Zn$, $^{144}Ce$, $^{46}Sc$, and $^{51}Cr$ retained 55% of the $^{65}Zn$ and less than 10% of the $^{144}Ce$ and $^{46}Sc$. Transfer of $^{51}Cr$ was not measurable. Zinc-65 loss during molting depended upon whether the zinc had been accumulated from food or from water. When uptake was from water, approximately 20% of the $^{65}Zn$ body burden was lost with the cast exoskeleton, whereas only 2.0% was lost when $^{65}Zn$ was accumulated from food. The potential role of Anonyx in the cycling of radioactivity in the marine environment is discussed. (auth)

**17902** (CONF-670503–, pp 462-73) ELIMINATION OF IODINE, COBALT, IRON, AND ZINC BY MARINE ZOOPLANKTON. Kuenzler, Edward J. (North Carolina Univ., Chapel Hill. Dept. of Environmental Sciences and Engineering).

Measurements of elemental elimination rates were made using zooplankton labeled by fallout from a nuclear test and upon zooplankton labeled with tracers. The rates at which elements were eliminated by zooplankton depended on the element, the animal species, and the time since they became labeled. In experiments performed soon after labeling, copepods had elimination rates of 1 to 6%/hr for I, 4 to 6%/hr for Co, and about 1%/hr for Zn; Pyrosoma, about 1%/hr for I and Zn, and 2 to 3%/hr for Co and Fe; salpidae, 8 to 19%/hr for Co; Sagitta, 22%/hr for I, 11%/hr for Co, and 3%/hr for Zn; euphausiids, 1%/hr for I and Co, and 5%/hr for Zn; pteropods, 5 to 6%/hr for I and Fe, and 1 to 3%/hr for Co and Zn. Filtration and ion-exchange techniques indicated the physical and chemical form of the eliminated products. Most of the iodine eliminated by zooplankton was probably $I^-$, but copepods also eliminated some cationic form. Much of the eliminated iron was particulate, but significant amounts were soluble anionic (Pyrosoma, Salpa) or non-exchangeable (Sagitta). Some eliminated cobalt was particulate, but most was cationic. Eliminated zinc also was frequently found in the particulate fraction, but exchangeable and non-exchangeable zinc were also eliminated. (auth)

**17903** (CONF-670503–, pp 505-8) SORPTION OF RADIOACTIVE NUCLIDES BY SARGASSUM FLUITANS AND S. NATANS. Simek, John E.; Davis, J. A.; Day III, C. E. (Texas Agricultural and Mechanical Univ., College Station); Angino, Ernest E. (Kansas Univ., Lawrence).

In the evaluation of radionuclides found associated with two species of Sargassum, specifically Sargassum fluitans and S. natans, an answer was sought as to how the radionuclides were associated with the algae. Tests were set up utilizing acid, base, and neutral washes to determine whether adsorption or absorption was the major nuclide-plant association. Results suggest that the radionuclides in question are absorbed, or metabolically fixed, rather than adsorbed to Sargassum natans and S. fluitans. (auth)

**17904** (CONF-670503–, pp 672-7) ACCUMULATION AND TRANSFER OF $^{45}Ca$ BY THE BIOTA OF A TAGGED CORNFIELD. Rose, George B.; Monk, Carl D.; Wiegert, Richard G. (Georgia Univ., Athens. Inst. of Ecology).

A study was made to determine distribution of calcium-45 within a corn crop at the Savannah River Plant and the transfer to old field weeds, insects, and soil. Corn seeds were soaked in a solution of calcium-45 and water prior to planting. At certain intervals content of $^{45}Ca$ was measured in the corn, and the biomass samples centered around the corn. Two species of ladybird beetle, one species of ant, two species of leafhopper, and species of click beetle were used, and the $^{45}Ca$ activity density was investigated during the summer months. Preliminary results show that any animal that contains isotope introduced into plants via tagged seeds must have: eaten plants that have recycled the isotope; eaten portions of the tagged plants; eaten animals that have consumed parts of the directly or indirectly tagged plants; or picked up leachate directly. (H.L.W.)

**17905** (CONF-670503–, pp 711-14) BIOELIMINATION OF TRACER $^{65}Zn$ BY THE LARGE MILKWEED BUG, ONCOPELTUS FASCIATUS, IN RELATION TO INFECTION WITH THE INTESTINAL FLAGELLATE LEPTOMONAS ONCOPELTI. Braswell, Joel H.; Hanson, William L. (Georgia Univ., Athens).

Groups of the large milkweed bugs, Oncopeltus fasciatus, some infected with the intestinal protozoan flagellates Leptomonas oncopelti, and some not infected were labeled with tracer $^{65}Zn$ via drinking water, then provided with unlabeled food and water for 14 days under the following experimental conditions: in the dark at 15 C, in the dark at 25 C, and in a growth chamber at 20 ± 2 C with a 12 hour photoperiod. Half of the bugs placed in the growth chamber were labeled for 10 days, while all other bugs were labeled for only one day. While temperature and time of labeling had significant effects on percent of tracer lost, no significant difference due to infection with L. oncopelti was detected between the elimination rates of the tracer in infected and non-infected groups. It is tentatively concluded that the protozoan does not affect food utilization by the host. (auth)

**17906** (CONF-670503–, pp 715-20) TRANSFER AND BIOELIMINATION OF TRACER $^{65}Zn$ DURING PREDATION BY SPIDERS ON LABELED FLIES. Breymeyer, Alicja; Odum, Eugene P. (Georgia Univ., Athens. Inst. of Ecology).

When theridid spiders, Steotoda triangulosa, were fed on houseflies labeled with $^{65}Zn$, the percent of the radioactive tracer transferred to the predator corresponded closely to the percent dry matter removed from the prey ($r = 0.6951$; $P < 0.01$). Twenty-two spiders ingested an average of about 53% of both tracer and dry matter contained in the labeled houseflies; 42% of radioactivity remained in the uneaten fly carcass and 5% was lost to the environment during the feeding process. A larger mean percentage (87) of tracer was ingested when agelinid spiders fed on much smaller prey, the fruit fly. Subsequent elimination of the ingested $^{65}Zn$ was significantly more rapid in lycosid spiders that were well fed than in similar spiders receiving no additional food. The most rapid bioelimination occurred in theridid females producing egg sacs, about 20% of the body burden being excreted with each egg mass laid. Bioelimination half-time ($Tb\frac{1}{2}$) averaged 13 days in a group of actively feeding theridid females laying 2 to 4 sacs each in 40 days as compared to a mean $Tb\frac{1}{2}$ of 68 days in an unfed, non-laying comparable group. It is tentatively concluded that $^{65}Zn$ is a good tracer for energy transfer during predation, and that its subsequent rate of elimination by the predator is an indicator of the amount of energy channeled into production. (auth)

**17907** (CONF-670503–, pp 721-4) THE EFFECT OF COPROPHAGY ON RETENTION AND BIOELIMINATION OF RADIONUCLIDES BY DETRITUS-FEEDING ANIMALS. Mason, William H.; Odum, Eugene P. (Georgia Univ., Athens. Inst. of Ecology).

Studies on bioelimination of ingested tracer $^{65}Zn$ by the wood-eating beetle, Popilius disjunctus, show the following: Ingestion of feces, previously chewed wood fragments, or both, is necessary for survival in this species. When the beetles are deprived of feces or chewed wood in the laboratory, they lose weight and

ultimately retain considerably less of the ingested tracer. Under these conditions most beetles die within three weeks. When allowed to ingest feces, the beetles not only maintain their weight but show a marked reduction in wood ingestion within a few days. Those deprived of feces continue degrading wood at an undiminished rate. It is concluded that coprophagic behavior enhances nutrition and favors the retention of ingested minerals. The concept of the "external rumen" is discussed as the probable mechanism by which many animals are able to utilize detritus of low nutritional quality as a source of nutrients and energy. (auth)

**17908** (CONF-670503–, pp 725-30) BIOELIMINATION OF TRACER $^{65}$Zn IN RELATION TO METABOLIC RATES IN MICE. Pulliam, H. Ronald; Barrett, Gary W.; Odum, Eugene P. (Georgia Univ., Athens. Inst. of Ecology).

The bioelimination rate of oral doses of $^{65}$Zn was significantly correlated with the rate of metabolism of three groups of white mice kept at three environmental temperatures (5, 10, 20 C). The temperature increase of 5 to 20 C resulted in a 1.8-fold decrease in the rate of metabolism and a 1.7-fold increase in the bioelimination half-time. However, within each temperature group, correlation between rates of bioelimination and metabolism of individuals was not statistically significant. Mice kept in a field enclosure in which the average temperature was about 24 C exhibited a more rapid rate of tracer bioelimination than any of the laboratory groups. It is tentatively concluded that differences in population metabolic rate of the order of 0.15 kcal/gram/day or greater will result in detectable differences in whole body $^{65}$Zn bioelimination but that the latter is not a sufficiently sensitive index to detect smaller differences in metabolic rate of individuals within the population. (auth)

**17909** (CONF-681006–, pp 25-8) COMMERCIAL IRRADIATION OF SHELLFISH WITH A PORTABLE SHIPBOARD IRRADIATOR. Novak, Arthur F. (Louisiana State Univ., Baton Rouge).

The commercial feasibility of using a shipboard irradiator for radiation preservation of shrimp was studied using biochemical, microbiological, and organoleptic tests as indexes of quality. One study was conducted with the irradiator mounted on the research vessel and the other with the same unit mounted on a low-boy trailer at dockside. In general, freshly caught and iced nonirradiated shrimp had a storage life of 14 to 17 days according to the conditions and location of catch. By comparison, freshly caught and iced irradiated shrimp had a storage life of 25 to 35 days according to the condition and location of catch. Use of the irradiator on shipboard was found to be extremely simple; it could be operated in adverse weather. It was concluded that shrimp can be irradiated on a commercial scale, but some question remained as to whether a shipboard or dockside irradiator offerred the advantage. (C.O.)

**17910** GLUTAMATE DECARBOXYLASE ACTIVITY AND THE CONCENTRATION OF GAMMA-AMINO-BUTYRIC ACID IN THE RAT BRAIN WITH WHOLE-BODY X-IRRADIATION. Sytinskii, I. A.; Shang, K'o-ch'in. Nerv. Sist., Leningrad Gos. Univ., Fiziol. Inst., No. 7, 47-50(1966). (In Russian).

Whole-body x-irradiation of rats at 800 R caused a 15% rise in the concentration of gamma-aminobutyric acid and glutamate decarboxylase (I) activity in the brain of the irradiated animals on the 4th to 6th day of radiation sickness. The quantitative determination of gamma-aminobutyric acid and I was done chromatographically from the 5th hr. to the 10th day of radiation disease. The I activity was judged by the increase in concentration of gamma-aminobutyric acid. (tr-auth)

**17911** MOLECULAR MECHANISMS OF POSTRADIATION PROCESSES IN THE BACTERIAL CELL. I. EXCISION OF PYRIMIDINE DIMERS AND DNA DEGRADATION AFTER A COMBINED ALPHA- AND UV-IRRADIATION OF E. COLI. Paribok, V. P.; Val'dshtein, E. A.; Tomilin, N. V. (Inst. of Cytology, Leningrad). Tsitologiya, 11: 93-103(Jan. 1969). (In Russian).

Effects of $\alpha$-irradiation on the excision of pyrimidine dimers from DNA and on DNA degradation process have been studied. Bacterial cells were grown in the presence of 2-$^{14}$C-thymine, irradiated and incubated in EM9 for 60 min at 37°C. The quantity of thymine dimers (TT and UT) was determined radiochemically in the acid insoluble fraction. DNA degradation was measured as a decrease of acid insoluble radioactivity in cell aliquots. In experiments with UV-irradiated (1000 erg/mm$^2$) E. coli 15T$^-$, after a postradiation incubation in the acid insoluble fraction only 0.24 (TT + UT) : T, instead of 0.44%, remains, which corresponds to 37.1% (TT + UT) calculated with regard to the amount of undegradated DNA. Preliminary $\alpha$-irradiation inhibited the excision of dimers: in the acid insoluble fraction 0.34% (TT + UT) : T or 50% TT + UT was found. This inhibition is proposed to be a result of an inactivating action of $\alpha$-particles on the excision enzymes. In experiments with E. coli $B_{s-1}{}_{Y}R$ (an UV-sensitive train) it was shown that after uv-irradiation these bacteria were unable to excise pyrimidine dimers and to degrade their DNA. The preliminary $\alpha$-irradiation of this strain induces both excision and degradation. This result is consistent with the hypothesis of two events involved in the excision processes; incision and excision. Alpha-rays imitated one of the steps, which is lacking in the strain $B_{s-1}{}_{Y}R$. The possible localization and sequences of these two steps are discussed. The DNA degradation induced by various doses of $\alpha$-irradiation is shown. The time-effect curves were found to consist of two components. For both strains uv-irradiation reduces the DNA degradation induced by $\alpha$-rays. (auth)

**17912** THERMAL REGULATION IN X-IRRADIATED DOGS SUBJECTED TO HEAT STRESS. Thomson, R. A. E.; Michaelson, S. M.; Quinlan, W. J. Jr. (Univ. of Rochester, N. Y.). Aerosp. Med., 40: 283-6(Mar. 1969).

Approximately seven years after 970 R upper-body (xiphoid process craniad), or 270 R whole-body x-irradiation (1000 kVp, 50-60 R/min, MAD), dogs were subjected for six hours to 105 F ambient temperature, 25 percent humidity. In addition, 1800 R localized-thyroid x-irradiated dogs were studied one to two years after irradiation. Non-x-irradiated dogs served as controls. The thermoregulatory ability of the animals was determined. Normal and x-irradiated dogs had differing thermoregulatory patterns. Upper-body x-irradiated dogs had a comparable response to that observed in the controls, namely, a gradual rectal temperature decrease, then increase to the preexposure level. Localized-thyroid x-irradiated dogs had a significant decrease in rectal temperature during the initial thirty minutes of exposure. Whole-body x-irradiated dogs had a progressive and significant increase in rectal temperature. Latent injury in the x-irradiated dogs is suggested by the differing thermoregulatory patterns to that noted in control dogs during heat stress. (auth)

**17913** NEW EVIDENCES OF IMMUNE GLOBULIN SYNTHESIS BY RAT TRANSPLANTABLE LYMPHOSARCOMA CELLS. Tsikarishvili, T. N.; Fel', V. Ya. (Inst. of Cytology, Leningrad). Tsitologiya, 11: 86-92(Jan. 1969). (In Russian).

The agar plaque technique of Jerne and Nordin (1963) was used for the study of the ability of rat transplantable lymphosarcoma cells to synthesize immune globulins. The data obtained suggest the appearance of cells producing antibodies (haemolysins) among tumor cells not later than 3 to 4 days after injection of antigen (sheep erythrocytes) into the tumor-bearing rats. Most demonstrative proved to be data obtained in rats, in which a total inhibition of their own immune reaction was obtained by the whole-body x-rays irradiation. (auth)

**17914** THE EFFECT OF X-RADIATION ON THE DNA SYNTHESIS AND KINETICS OF CELL POPULATION IN THE REGENERATING RAT LIVER. I. IRRADIATION OF CELLS AT THE $G_1$-PERIOD. Polishchuk, A. M. (Inst. of Cytology and Genetics, Novosibirsk, USSR). Tsitologiya, 11: 48-55(Jan. 1969). (In Russian).

Male Wistar rats were partially hepatectomized so that $^2/_3$ of the liver was removed. Ten hours after hepatectomy the animals were exposed to x-radiation (100 R). Eleven, 14, 17, 20, 23, 26, 29, 32, 35 and 38 hours after the operation the animals were injected with 0.3 c/g $H^3$TdR intraperitoneally and sacrificed an hour thereafter. Liver slices were prepared for obtaining the mitotic index, the index of labeled cells and the average number of grains per labeled nucleus. It has been established that the rate of incorporation of $^3$H-thymidine into individual cells of regenerating liver at the second half of S-period is higher than that at the first half. The irradiation of cells at the $G_1$-period not only blocks their transition to the S-period, but also inhibits the rate of DNA synthesis in such cells after this $G_1$–S block is removed. (auth)

**17915** DESIGN OF NEW RADIOPHARMACEUTICALS. Wagner, Henry N. Jr.; Emmons, Hamilton (Johns Hopkins Medical Inst., Baltimore, Md.). pp 57-67 of Symposium on Computers and Scanning. Hidalgo, John U. (ed.). New York, Society of Nuclear Medicine, 1967.

See CONF-651210.

The use of tracer techniques in biomedical problems and the characterization of a radiopharmaceutical are given. The physical and biological aspects of dose and distribution and movement within the organism are reviewed as are the detection parameters. The possibilities of using a much wider range of nuclides is also considered. (C.O.)

**17916** THE XIth CONGRESS OF THE INTERNATIONAL SOCIETY OF HAEMATOLOGY. Abstracts of Papers. Presented at the Plenary Sessions of the Congress Held at the University of Sydney, Between the 21st of August and the 26th of August 1966.

Sydney, Australian Red Cross Society, 1966. 385p. (In English and French). (CONF-660840-(Vol.2)).

Abstracts of 30 papers presented at the Congress are included. Among the topics included were biological effects of radiation, leukocyte kinetics, iron deficiency, hemolysis, neoplasia, leukemia, hemostasis, abnormal hemoglobins, red cell metabolism, and cellular hematology. Author and subject indexes are included. (H.L.W.)

**17917** THE XIth CONGRESS OF THE INTERNATIONAL SOCIETY OF HAEMATOLOGY. Papers Presented at the Plenary Sessions of the Congress Held at the University of Sydney, Between the 21st of August and the 26th of August 1966. Sydney, Australian Red Cross Society, 1966. 455p. (CONF-660840-(Vol.1)).

A separate abstract was prepared for one chapter in the section on red cell production and destruction. Other sections are included on lymphoid cells, leukemia, anemia, thrombosis, blood genetics, white cell and platelet physiology, red cell metabolism, and the structure of hemoglobin. Author and subject indexes are included. (H.L.W.)

*For an abstract of the individual chapters see: 17918.*

**17918** MIGRATION STREAMS OF HAEMATOPOIETIC STEM CELLS. Barnes, D. W. H.; Loutit, J. F. (Medical Research Council Radiobiological Research Unit, Harwell, Eng.). pp 211-18 of XIth Congress of the International Society of Haematology. Sydney, Australian Red Cross Society, 1966.

See CONF-660840-(Vol.1).

A review of the literature on hematopoietic stem cells is presented. It was concluded that stem cells circulate in the blood stream not only in embryonic life when other migrations are taking place, but throughout life. The source of stem cells is in myeloid tissue including red bone marrow, fetal liver, and spleen. This was repeatedly confirmed in experiments involving radiation chimeras. From transfer experiments it was concluded that bone marrow was the source of stem cells not only for marrow but also for lymph nodes and thymus. The effect of thymectomy in radiation chimeras showed that the thymus was not essential for recovery provided that sufficient lymphocytes were present in the restorative inoculum. (H.L.W.)

**17919** QUINONE LEVEL IN ANIMALS AFTER EXPOSURE TO IONIZING RADIATION. Berdina, M. A.; Kuzin, A. M.; Uteshev, A. B. (Inst. of Biophysics, Moscow. Inst. of Experimental Biology, Alma Ata, USSR). Izv. Akad. Nauk Kaz. SSR, Biol. Nauk., No. 1, 67-70(Jan. 1968). (In Russian).

Rats and guinea pigs were exposed to 900 R of whole-body irradiation. Six hours after exposure the level of o-quinones in the liver rose by 5.5%. The peak occurred 12 hours after exposure. Another series of experiments on guinea pigs showed a sharp decrease in quinone concentration in the kidneys and brains within 24 hours of exposure. Since tyrosinase is activated in the skin and the tyrosine content of the blood and tissues of irradiated animals rises, the increased amounts of quinones are drawn into several chain biochemical processes, exerting a toxic effect and killing the animal. The resultant o-quinones seem to play an important part in the development of radiation sickness. (JPRS)

**17920** CHANGES IN THE CONTENT OF BIOGENIC AMINES IN THE TISSUES OF ANIMALS WITH DIFFERENT DEGREES OF RADIOSENSITIVITY. Musagelieva, G. M. (Inst. of Biophysics, Moscow). Izv. Akad. Nauk Kaz. SSR, Ser. Biol. Nauk, No. 4, 77-80 (July-Aug. 1968). (In Russian).

Irradiation of rats and guinea pigs (800 R and 500 R) produced wavelike changes in the catecholamine content of the animals. Epinephrine mostly decreased in the brains of rats, but it increased in guinea pigs in the early stage of radiation sickness. The norepinephrine content in the brains of both stockbred and purebred mice was below the control level throughout the observation period, but it accumulated to 210.7% in the adrenals. The DOPA concentration in the brains of the stockbred rats remained unchanged, whereas it increased in the Wistar rats and guinea pigs. The DOPA level rose in the adrenals of the stockbred rats, reaching a peak two hours after irradiation while changing in wavelike fashion in the purebred rats. No direct correlation can be established between the catecholamine content and radiosensitivity of animals. Nevertheless, these active compounds and their precursors play an important role in the organism's reaction to radiation by participating in the regulation of cardiovascular activity, in conduction of impulses in nerve tissue, and in intensification of the oxidation processes. The wavelike nature of the changes in catecholamine content in the adrenals is probably caused by impairment of their intracellular synthesis following irradiation. (JPRS)

**17921** EFFECT OF $\gamma$ IRRADIATION ON COLLAGEN. I. GEL FORMATION AND CHANGES OF OPTICAL ROTATION AND VISCOSITY OF GELATIN AND COLLAGEN SOLUTIONS BY $\gamma$ IRRADIATION. Kubota, Minoru; Kimura, Shigeru (Tokyo Univ. of Fisheries). Hikaku Kagaku, 14: 105-11(Oct. 1968). (In Japanese).

Using collagen, a typical fibrous protein, the effect of $^{60}Co$ $\gamma$ radiation or gel formation, viscosity, and optical rotation was investigated. First, $\gamma$ irradiation of gelatin (denatured collagen) at a concentration of 0.9% in water resulted in gel formation at 10°C. An insoluble gel of 20% formed at a dose of $1.90 \times 10^5$ R; 90% at a dose of $3 \times 10^5$ R; and nearly 100% at a dose of $2 \times 10^5$ R. The gel formation induced by $\gamma$ irradiation was related to the concentration of gelatin and could not be observed below 0.3% even at doses above $10^7$ R at 10°C. In the collagen solution, the critical concentrations of gel formation were 0.12% at a dose of $1.90 \times 10^5$ R, 0.26% at a dose of $1.1 \times 10^5$ R at 10°C, and 0.095% at a dose of $3.3 \times 10^5$ R at 0°C. At 0°C, larger doses were required to induce gel formation in collagen solutions of the same concentration. Both the viscosity and optical rotation of collagen decreased after irradiation and the former change was greater. It was suggested that $\gamma$ irradiation caused the collagen molecule that is composed of a three-stranded helix to undergo scission of a strand at the first stage and that at higher doses of irradiation, the scission of molecular chains proceeded and resulted in partial disruption of the helix. During the partial disruption process, the collagen molecule underwent some intermolecular linkages that resulted in gel formation and finally at larger doses the gel was resolubilized by further scissions of the molecular chains. It was also found that low temperature suppressed the changes in viscosity and optical rotation but accelerated gel formation and resolubilization of the gel. (TSS) (NSA of Japan)

**17922** RAPID IN VIVO ASSAY FOR SV40 TUMOR IMMUNITY IN HAMSTERS. Coggin, Joseph H. Jr.; Ambrose, Kathleen R. (Univ. of Tennessee, Knoxville). Contract AT(40-1)-3646. Proc. Soc. Exp. Biol. Med., 130: 246-52(Jan. 1969).

The appearance of several viral or viral stimulated neoantigens in SV40 transformed hamster cells is well documented. The detection of the presence of transplantation antigen in a tumor cell preparation capable of stimulating an immune reaction and of suppressing the development of SV40 induced tumors in hamsters is a prolonged procedure requiring several hundred days for completion. A 5-day in vivo method for detecting transplantation immunity in a homologous hamster system employing immunodiffusion chambers and x-irradiated in vitro cells is described. (C.H.)

**17923** AUTOXIDATION PRODUCTS OF CHOLESTEROL IN AERATED SOLS AND IRRADIATED SPRAY-DRIED EGG YOLK. Chicoye, Etzer. Madison, Wis., Univ. of Wisconsin, 1968. 112p.

Thesis.

Several researchers have reported that 7-ketocholesterol and epimeric 7-hydroxycholesterols were the major products of autoxidized cholesterol. In the present investigation, these oxygenated cholesterol derivatives were synthesized and purified for use as reference compounds in subsequent studies on the autoxidation of cholesterol in spray-dried yolk. Chemical and physical properties of the oxygenated cholesterol derivatives were discussed. When a cholesterol sol was aerated for about 6 hr at about 80°C, extensive autoxidation was observed. The major autoxidation products, as detected by TLC, were 7-ketocholesterol, 7$\alpha$- and 7$\beta$-hydroxycholesterols, and an unknown compound with a $R_c$ value only slightly higher than that of 7-ketocholesterol. With overlapping of the 7-ketocholesterol and compound X bands on preparative TLC plates, purified compound X could not be isolated. To obviate this overlapping problem, the autoxidized cholesterol sol was treated with alkali to decompose the 7-ketocholesterol but not compound X. From infrared analysis, the structure of compound X was presumed to be a cholesterol oxide. Isolated compound X and synthesized cholesterol-5$\beta$,6$\beta$-oxide had identical infrared spectra, $R_c$ values (TLC), relative retention times (GLC), melting points and color reactions. Mass spectroscopy and elemental analysis were also used for confirmation of compound X structure. Samples of fresh egg yolk and spray-dried egg yolk were studied by TLC and GLC to assess the presence of autoxidation products of cholesterol. When spray-dried yolk was irradiated with energy from either a 40-watt fluorescent lamp for about 280 hr or direct summer sunlight for 5 hr, 7-ketocholesterol, 7$\alpha$- and 7$\beta$-hydroxycholesterols, cholestane-3$\beta$, 5$\alpha$,6$\beta$-triol and cholesterol-5$\beta$,6$\beta$-oxide were detected in the non-saponifiable matter by TLC or GLC. (TSS) (Disser. Abstr.)

**17924** STUDY ON THE LINGUAL MUCOSA ABSORPTION WITH RADIOISOTOPE TECHNIQUE. Ito, Ushio (Kanazawa Univ., Japan). Kanazawa Irigaku Sosho, 80: 138-52(July 1967). (In Japanese).

Mucous membrane absorption was studied with a radioisotope technique. After pouring 150 $\mu$Ci of $Na^{131}I$ solution into the case fixed on the mucous membrane of the dorsum linguae of rabbit, $^{131}I$ activity appearing in the circulating blood was determined repeatedly with time and compared with $^{131}I$ activity appearance after subcutaneous injection. Secondly, $^{131}I$ remaining in the applied region and $^{131}I$ uptake in the thyroid gland and submaxillary glands were examined with microautoradiogram as well as paperchromatogram. Furthermore, $^{131}I$ appearance in the blood was recorded continuously with the detector through a ratemeter-recorder system placed over the precordium. Absorption rates ($R\ min^{-1}$) were compared between normal control group and inflammation group induced by 0.1N HCl painting or 1000 R of $^{60}Co$ irradiation. The absorption rates were calculated and the following results were obtained. Absorption from the mucous membrane of dorsum linguae started five minutes after application, reached at maximum at two hours later, decreased remarkably after three hours and was no longer observed at 12 hours. Absorption speed from mucous membrane was about one fifth of that in subcutaneous injection; it was proved from lingual $^{131}I$ remaining and gastric secretion of $^{131}I$ that almost all radioactivity applied was absorbed within two hours after application of $Na^{131}I$ solution. The microautoradiograms of lingual tissue showed a large amount of $^{131}I$ distributed in submucous connective tissue as early as 30 minutes after application of $Na^{131}I$ solution. The absorption rates calculated from absorption curves increased in artificially induced inflammation groups; normal control group: 0.1N HCl painting group: $^{60}Co$ 1000 R irradiation group = 0.0346 : 0.0778 : 0.0552 = 1.00 : 2.24 : 1.59. A part of the above-mentioned results could be applied to the clinical diagnosis of mucous diseases. (NSA of Japan)

**17925** CHANGES IN THE ENZYME LEVELS OF MOUSE ORGANS AFTER LEUKEMOGENIC DOSES OF X-RAY AND TREATMENT WITH RADIATION LEUKEMIA PROTECTION FACTOR. Yip, L. C.; Blair, N.; Yu, P. L.; Hodes, M. E. (Indiana Univ. Medical Center, Indianapolis). Israel J. Med. Sci., 4: 1188-94(Nov.-Dec. 1968).

The effect of fractionated leukemogenic doses of x-ray, followed by injections of radiation leukemia protection (RLP)-containing substances, on the specific activity of alkaline phosphatase (AP), lactate dehydrogenase (LDH) and deoxyribonuclease II of liver, spleen, serum and thymus was studied. The enzyme levels rose within 1 to 3 days after each exposure to 180 R. RLP (sheep serum) prevented or lessened the increase of the three enzymes of spleen, and of liver and serum LDH and AP. The differences of the means determined over the 28-day period were significant for these enzymes. In a separate experiment, substances already tested for RLP activity were examined for their ability to lower liver enzyme specific activity seven days after x-irradiation and injection. The correlation was very good for LDH and AP. These observations may provide a basis for a rapid assay method for RLP activity. (auth)

**17926** STRONGLY RADIOACTIVE PARTICLES INGESTED PER OS BY MICE. Yoshida, Sachiko; Oki, Iwashiro (Osaka Public Health Inst.). Osaka-Furitsu Koshueisei Kenkyusho Kenkyu Hokoku, No. 4, 55-7(Mar. 1967). (In Japanese).

At the time of the third Chinese nuclear test, radioactive particles falling on the roof of the Osaka institute were collected; their physical properties and their metabolism in male mice, weighing 21.0 to 36.8 g, after oral administration, were examined. The results obtained were as follows: The strongly radioactive particles were spherical or ovoid, 10 to 20 $\mu$ in diameter, and yellowish brown or reddish brown in color. Their radioactivity was nearly proportional to their size, about $1 \times 10^4$ cpm for 1500 $\mu^3$, and $2 \times 10^4$ cpm for 3000 $\mu^3$. The radioactivities decayed somewhat rapidly immediately after collection, then gradually. In the oral administration to mice, the nuclides with more than 10-day half life predominated. By $\gamma$-ray spectrometry, the two peaks at 0.3 and 1.7 MeV due presumably to Ba- and La-140, and the peak at 0.78 to 0.8 MeV due to Zr-Nb-95 were primarily observed. No difference in composition was observed among the several particles. The particles ingested orally by mice were discharged into the feces within 20 hours (within 20 to 27 hours in only one mouse); their recovery was 100%. No radioactivity was observed in the urine. After 450°C incineration of mice which had discharged radioactive particles, there was no measurable radioactivity in the ashes. (NSA of Japan)

**17927** UPTAKE OF TRITIATED THYMIDINE IN THE ROOT TIP MERISTEM OF VICIA FABA (L). Scheuermann, W.; Taegder, K. (Technische Univ., Hanover). Radiat. Res., 36: 483-92(Dec. 1968).

A quick and accurate method for determination of tritium-labeled thymidine ($^3H$-TdR) in tissue was discussed. After $^3H$-TdR incorporation into the root tip meristem of Vicia faba, total $^3H$ activity as well as $^3H$-DNA activity was measured by liquid scintillation counting. The incorporation rate of $^3H$-TdR using various parameters was examined—for example, the amount of incorporated $^3H$-TdR as a function of duration of treatment or as a function of thymidine concentration in the nutrient solution. The experimental results together with other data allowed the calculation of the average number of incorporated thymidine molecules per labeled cell nucleus. This was necessary to interpret quantitatively the biological effects of incorporated radionuclides. (auth)

**17928** REDUCTION IN THE ABSORPTION AND RETENTION OF DIETARY STRONTIUM IN MAN BY ALGINATE. Carr, T. E. F.; Harrison, G. E.; Humphreys, E. R.; Sutton, Alice (Radiobiological Research Unit, Harwell, Eng.). Int. J. Radiat. Biol., 14: 225-33(1968).

The absorption and retention of $^{47}Ca$ and $^{85}Sr$ were compared for four volunteers on a normal diet with and without a supplement of sodium alginate. The alginate was given for seven days in amounts approximately chemically equivalent to the dietary calcium. Alginate decreased the retention of $^{85}Sr$ and $^{47}Ca$ by about 70 and 7% respectively. The mean ratio for the absorption of $^{85}Sr$ on the supplemented to that on the unsupplemented diet was 0.23. This ratio was greater than that derived from earlier results for subjects given alginate in milk alone. The urinary and faecal excretion as well as the plasma concentration of stable sodium, potassium, magnesium, calcium, strontium, barium and phosphorus, were measured. (auth)

**17929** EFFECT OF X-RADIATION ON TRANSFER RIBONUCLEIC ACID. Skinner, L. G. (Christie Hospital and Holt Radium Inst., Manchester, Eng.). Int. J. Radiat. Biol., 14: 245-56(1968).

When aqueous solutions of uncharged transfer ribonucleic acids of liver, yeast and E. coli origin were irradiated, their acceptor activities for leucine, phenylalanine and lysine were inhibited by different amounts. Both rate and final extent of acceptance were reduced. The degree of inhibition was a function of dose and was less for irradiation in nitrogen than in air. Lysine acceptor activity showed the greatest sensitivity in t-RNA from all three sources. Exposure of uncharged liver t-RNA to 50 kRads x radiation resulted in about 50% inhibition of its ability to transfer $^{14}C$-L-lysine to polylysine in the presence of poly A and a liver ribosomal system. Results indicated radiation damage to the regions associated with transfer function as well as to acceptor sites. By irradiation of $^{14}C$-lysine-charged t-RNA it was possible to show that both the ribosomal binding site and the anticodon region were sensitive to ionizing radiation. (auth)

**17930** RADIATION-INDUCED DOUBLE-STRAND SCISSION OF THE DNA OF MAMMALIAN METAPHASE CHROMOSOMES. Corry, P. M.; Cole, A. (Univ. of Texas, Houston. M. D. Anderson Hospital and Tumor Inst., Houston, Tex.). Contract AT(40-1)-2832. Radiat. Res., 36: 528-43(Dec. 1968).

The molecular weight distribution of double-stranded mammalian (hamster) DNA was determined by ultracentrifugation of isolated metaphase chromosomes previously layered onto sucrose gradients containing high salt concentrations to dissociate the protein and nucleic acid components. In untreated controls the distribution (as determined by counting the incorporated radioactivity in the resultant fractions) exhibited a peak at $225 \times 10^6$ daltons. Inclusion of mercaptoethanol and hydroxylamine into the gradients produced no significant change of these sedimentation patterns. Gamma-radioinduced reduction in the number and average molecular weights was used to calculate a value of $1.05 \times 10^{11}$ double-strand breaks/gram Rad, equivalent to about 600 eV/break. No significant difference was observed for chromosomes irradiated either before or after isolation from intact mitotic cells. Irradiation in the presence of cystamine resulted in at least a sevenfold reduction in the apparent double-strand scission. The observed sedimentation patterns were compared with those generated by a theoretical computer simulation of radioinduced degradation which assumed random selection and breakage of molecules. These results suggested that at least 80 to 90% of the isolated DNA was distributed approximately normally with a mean molecular weight of about $200 \times 10^6$ daltons and a standard deviation of about $50 \times 10^6$ daltons. (auth)

**17931** TRITIATION OF LYSOZYME BY THE FREE-RADICAL INTERCEPTOR METHOD AND DETERMINATION OF THE TRITIUM DISTRIBUTION AMONG INDIVIDUAL RESIDUES OF THE CHROMATOGRAPHICALLY HOMOGENEOUS PROTEIN. White, Frederick H. Jr. (Dept. of Health, Education, and Welfare, Bethesda, Md.). Radiat. Res., 36: 470-82(Dec. 1968).

Lysozyme was tritiated by the free-radical interceptor method, which involved reaction of the carbon free radicals, resulting from $\gamma$ irradiation of the lyophilized protein in a vacuum, with tritiated hydrogen sulfide. This technique resulted in a high yield of tri-

tiated enzyme which was chromatographically indistinguishable from the native protein. To characterize this material with respect to its tritium distribution, it was first reduced, carboxymethylated, and digested with chymotrypsin. The peptides were separated and purified by ion exchange chromatography and electrophoresis and then analyzed to determine the specific activities of 78 of the 129 residues in the protein chain. The tritium was found to be broadly distributed, with only 12 residues apparently devoid of label. The relative specific activity, defined as the ratio of the specific activity of a given residue to the average specific activity for all residues of the same kind within the protein, did not exceed the value of 3.73 for isoleucine at position 88. A distinct spatial relationship was seen among the more heavily labeled residues when these results were related to the x-ray diffraction model of lysozyme. Thus, residues 16, 18, 19, 21, 23, 29, 31, and 32 could be grouped with 105, 110, 113, and 115; these highly labeled residues were close to a strongly hydrophobic region. Another heavily labeled area involved residues 50, 54, 57, 83, 84, and 88. In addition, residues 1 and 6 at the amino end of the chain were heavily labeled, as were 118, 121, and possibly 119 at the carboxyl end. This distribution of tritium appeared to reflect the secondary free-radical distribution in the irradiated protein. These observations confirmed previous indications that the secondary distribution was influenced by the conformation of the protein molecule. (auth)

**17932** FORMATION AND REACTIONS OF HYDROGEN ATOMS IN GAMMA-IRRADIATED DEOXYRIBONUCLEIC ACID GELS. Holmes, D. E.; Weiss, J. J. (Univ. of Newcastle upon Tyne, Eng.). Int. J. Radiat. Biol., 14: 187-92(1968).

The electron-spin-resonance spectra of $\gamma$-irradiated DNA gels, frozen solutions of DNA, and frozen solutions of thymine-containing constituents of DNA with and without the addition of the dihydrogenphosphate anion were described. It was shown that the phosphate moiety in DNA and nucleotides was associated with the formation of hydrogen atoms which in turn reacted with the thymine and deoxyribose moieties in the DNA. This resulted in the formation of the thymine hydrogen-atom addition radical (dihydrothymil-5-l) as well as the deoxyribose radical. The effects of temperature on the yield of radicals was also studied. (F.M.M.)

**17933** EFFECTS OF WHOLE-BODY X-IRRADIATION ON NUCLEAR RNA POLYMERASE ACTIVITIES IN RAT TISSUES. Omata, Saburo; Ichii, Shogo (National Inst. of Radiological Sciences, Chiba, Japan). J. Biochem. (Tokyo), 63: 695-700(June 1968).

$Mg^{2+}$-dependent and $Mn^{2+}/(NH_4)_2SO_4$-dependent RNA polymerase [nucleosidetriphosphate: RNA nucleotidyltransferase, EC 2.7.7.6] activities in liver-nuclei increased by about 40% over the respective controls 24 hr after whole-body x irradiation (650 R) of intact, ad libitum fed rats, and then the activities turned to subcontrol levels during the 10 days postirradiation. Similar changes in the activities of liver RNA polymerase were observed on irradiation for fasted rats but not for adrenalectomized animals. The induction of RNA polymerase as well as of tyrosine transaminase [L-tyrosine: 2-oxoglutarate aminotransferase, EC 2.6.1.5] by cortisol administration was not influenced by x irradiation. The effects of x irradiation on $Mg^{2+}$-dependent and $Mn^{2+}/(NH_4)_2SO_4$-dependent RNA polymerase activities in testis, spleen and thymus of rats were also described. (NSA of Japan)

**17934** THE MECHANISM OF RADIATION ACTION IN LEUKEMOGENESIS. IV. IMMUNE IMPAIRMENT AS A COLEUKEMOGENIC FACTOR. Haran-Ghera, N.; Peled, A. (Weizmann Inst. of Science, Rehovoth, Israel). Israel J. Med. Sci., 4: 1181-7(Nov.-Dec. 1968).

Rabbit antimouse thymocyte serum (ATS), the potent immunodepressive drug, acted as a coleukemogenic agent in C57BL/6 mice. Administration of ATS to intact or thymectomized adult C57BL/6 mice inoculated with a leukemogenic cell-free filtrate prepared from irradiated nonleukemic tissues of C57BL mice caused lymphatic leukemia development in 78 to 90% of the treated mice at a mean latent period of 96 to 98 days. Omitting the ATS treatment in otherwise similarly treated hosts reduced the lymphoma incidence to 7 to 20% and increased the mean latent period for tumor development. Thymectomy in the neonatal period of life had only a slight coleukemogenic effect in C57BL/6 mice. (auth)

**17935** STUDIES OF THE LATENT PERIOD. I. PRIMARY ANTIBODY IN GUINEA PIG LYMPH NODES 7½ MINUTES AFTER INTRODUCTION OF CHICKEN ERYTHROCYTES. Litt, Mortimer (Boston City Hospital, Harvard Medical School, Boston). Cold Spring Harbor Symp. Quant. Biol., 32: 477-92(1967).

From Symposia on Quantitative Antibodies, Cold Spring Harbor, N. Y. See CONF-670647-(Vol.32).

Chicken erythrocytes (C-RBC) were injected into the footpads of guinea pigs and the histologic reactions were studied in the draining lymph nodes. The C-RBC appeared in the node within 10 seconds and began to lyse within 7½ minutes, predominantly around the medullary aspect of the cortical follicles. In animals actively immunized with C-RBC, reactions occurred within ½ minute were heightened, were widely distributed, and included the lymphoid follicles. In passively immunized animals (with antibody derived from rabbit serum or guinea pig lymph nodes), the reactions were massive, rapid (½ minute), and prominent in the subcapsular sinus. Cross-reactions were strong with other avian erythrocytes, and much less so with RBC from all other animal phyla. Similar results were obtained in neonates, and embryos injected in utero. The hemolytic reactions were virtually abolished by pretreatment with 500 R whole body x-irradiation or cyclophosphamide administered on each of four days preceding injection of C-RBC. The data are interpreted as indicating that primary anti-erythrocyte antibodies may be produced without a significant latent period. (auth)

**17936** IMMUNOLOGICAL CROSS REACTION BETWEEN MOUSE LEUKEMIA VIRUSES INDUCED BY THE INOCULATION OF CELL FREE FILTRATE AND BY THE X-RAY IRRADIATION. Rokutanda, Makoto (Kyoto Univ.). Annu. Rep. Inst. Virus Res., Kyoto Univ., 9: 105-16(Dec. 1966).

In order to know the mechanism of leukemogenesis, a study was made on the biophysical and antigenical properties of virus particles produced by two leukemia cell lines, which were SC-1 cells originating from leukemia tissue in S-mice, induced by inoculation of cell-free filtrate prepared from spontaneous leukemia tissue of SL-mice, and SX cells obtained from leukemia cells induced by x rays in S-mice. The results obtained were as follows. The virus particles obtained from SC-1 cells and SX cells were purified by density gradient centrifugation. They both had buoyant densities of 1.16 to 1.18 g/ml in potassium tartrate solution. The distribution of $^{32}P$ radioactivity in the virus particles, given by the Schmidt–Thanhauser method, was 61% in lipid, 21% in RNA, 6% was in DNA, and 12% in the residual fraction. DNAase treatment before density gradient centrifugation reduced remarkably the radioactivity in the DNA fraction, but RNAase treatment did not affect the RNA fraction. This indicated that RNA could be enclosed in the virus particle, protected from environmental affections. A cross reaction between SC-1 and SC virus was observed by the fluorescent antibody technique, using anti-purified virus rabbit serum. A cross reaction of transplantation immunity was also observed between SC-1 and SX cells, but SX cells were less sensitive to immunization with homologous (SX) or heterologous (SC-1) cells than SC-1 cells. It seemed by this observation that there were common antigenic structures in the tumor antigen in the leukemias induced by different methods. (NSA of Japan)

**17937** CELL INTERACTIONS IN THE INDUCTION OF ANTIBODY FORMATION. Feldman, Michael; Gallily, Ruth (Weizmann Inst. of Science, Rehovoth, Israel). Cold Spring Harbor Symp. Quant. Biol., 32: 415-21(1967).

From Symposia on Quantitative Antibodies, Cold Spring Harbor, N. Y. See CONF-670647-(Vol.32).

The capacity of macrophages from x-irradiated mice to elicit antibody production in x-irradiated recipients after interaction with antigen in vitro was studied. After in vitro interaction with antigen macrophages from normal animals elicited antibody formation in mice irradiated with 550 R of whole-body x ray 2 days previously. Lymphocytes alone did not initiate antibody production to Shigella antigen in x-irradiated animals, and required macrophages. Lymphoid-free macrophage populations obtained from in vitro culturing of peritoneal cells elicited antibody production in x-irradiated recipients. Mice x irradiated with doses of 550 to 950 R, and inoculated with normal macrophages incubated with antigen produced antibody titers that decreased with the dose of irradiation. Formation of antibodies was not elicited by injection of antigen alone. Macrophages irradiated in vitro with Shigella antigen were incapable of eliciting antibody production in x-irradiated recipients. X irradiation of macrophages did not suppress the phagocytic capacity of the cells. (BBB)

**17938** CELLULAR EVENTS DURING THE FORMATION OF ANTIBODY. Ellis, Susan T.; Gowans, J. L.; Howard, Jonathan C. (Oxford Univ.). Cold Spring Harbor Symp. Quant. Biol., 32: 395-406(1967).

From Symposia on Quantitative Antibodies, Cold Spring Harbor, N. Y. See CONF-670647-(Vol.32).

The development after irradiation of antibody cells that arise in the spleen and the identity of the precursor cells in the primary response to sheep erythrocytes are described. Rat lymphocytes labeled in vivo and in vitro with $^3H$-labeled uridine were used. Restoration of hemolysin response after doses of $^{60}Co$ $\gamma$ irradiation ranging from 600 to 1000 R was studied. Hemolysin response was restored in rats by syngeneic lymphocytes after doses of 1000 R. Doses of 600 and 850 R produced progressively lower

hemolysin titers in restored rats. Restorative capacity of combined intravenous injection of peritoneal exudate cells and sheep erythrocytes given 24 hr after 600 R also was studied. The ability of lymphocytes to restore antibody formation to sheep erythrocytes in rats irradiated with 600 R was studied at the cellular level by means of plaque assay. The peak of the restored response was delayed by ~24 hr compared to normal. Synthesis of DNA in plaque-forming cells and their precursors was studied in rats injected with sheep erythrocytes and infused intravenously with $^{3}$H-labeled thymidine. The efficiency of small lymphocytes to restore antibody response to sheep erythrocytes in irradiated rats, as measured by formation of labeled plaque-forming cells (PFC) in spleen was similar in normal and irradiated rats. A high proportion of PFC were not labeled by $^{3}$H-thymidine, which suggested existence of a nondividing precursor cell. In the spleen of rats irradiated with 1000 R, no DNA synthesis was observed. Large cells in the white pulp with pyroninophilic cytoplasm incorporated large amounts of $^{3}$H, but none was incorporated by the red pulp. (BBB)

**17939** COLD SPRING HARBOR SYMPOSIA ON QUANTITATIVE BIOLOGY. VOLUME XXXII. ANTIBODIES. Cold Spring Harbor Symp. Quant. Biol., 32: 1-619(1967). (CONF-670647-(Vol.32)).

Separate abstracts were prepared for three chapters of the symposium. Sixty-three additional chapters are included on various aspects of antibodies and immune reactions. Author and subject indexes are included. (H.L.W.)

*For abstracts of individual chapters see: 17935, 17937, and 17938.*

**17940** SYNTHESIS OF URIDINEDIPHOSPHO-[6-$^{3}$H] GLUCOSE WITH A CELL-FREE EXTRACT OF PHYTOPHTHORA CINNAMOMI. Wang, M. C.; Bartnicki-Garcia, S. (Univ. of California, Riverside). Anal. Biochem., 26: 412-44(Dec. 1968).

Several procedures have been published for the enzymic synthesis of uridinediphospho-[$^{14}$C]glucose, but apparently there are no reports on the enzymic synthesis of tritiated UDPG. An attempt to prepare UDP-[6-$^{3}$H] glucose using a partially purified yeast pyrophosphorylase, routinely employed in the synthesis of UDP-[$^{14}$C]glucose, resulted in a total loss of tritium to the medium (6), due perhaps to a spurious enzymic activity present in the pyrophosphorylase preparation. We have found that a crude pyrophosphorylase from the mycelium of the phytopathogenic funcus, Phytophthora cinnamomi, may be effectively employed for the synthesis of UDPG tritiated in the glucosyl moiety without labilization of the tritium atoms. The method involves the synthesis of UPD-[6-$^{3}$H] glucose from [6-$^{3}$H]glucose-6-phosphate by a mixture of purified phosphoglucomutase ($\alpha$-D-glucose-1,6-diphosphate: $\alpha$-D-glucose-1-phosphate phosphotransferase, EC 2.7.5.1) and a crude UDP-glucose pyrophosphorylase (UTP: $\alpha$-D-glucose-1-phosphate uridylyltransferase, EC 2.7.7.9) from P. cinnamomi. The reaction was driven to completion in the direction of UDPG synthesis by the inclusion of purified inorganic pyrophosphatase (pyrophosphate phosphohydrolase, EC 3.6.1.1). (auth)

**17941** KINETICS OF THE $^{239}$Pu METABOLISM IN THE CASE OF PROLONGED PERORAL ADMINISTRATION. Buldakov, L. A.; Erokhin, R. A.; Nifatov, A. P. (Inst. of Biophysics, Moscow). Radiobiologiya, 8: 900-7(1968). (In Russian).

In experiments on 337 rats the distribution in the internal organs, resorption in the gastrointestinal tract, and kinetics of the accumulation of a citric acid solution of $^{239}$Pu administered perorally daily at doses from 0.01 to 10 $\mu$Ci per day were investigated. It was established that the resorption of the isotope in the intestines does not depend on the amount introduced and comprises 0.058 to 0.066%. Of the resorbed amount of plutonium, 71 to 83% is retained in the skeleton, 10.4 to 20% in the liver, 2.5 to 6.5% in the kidneys, and 2.2 to 7.6% in the lungs. The distribution of the isotope in the internal organs is diffuse, while in the lumen of the gastrointestinal tract it is diffuse and in the form of "stars" of tracks—particles from fragments of plant cells of food masses, from mucous, eroded and ulcerated surfaces. The accumulation of plutonium in the internal organs is described by an exponential function for the skeleton, while the radiation dose rate increases during the entire life of the animal. In the large intestines, the dose rate is practically unchanged during the period from the first to 600th day. (JPRS)

**17942** INFLUENCE OF PREPLANTING IRRADIATION OF WHEAT SEEDS ON THIAMINE BIOSYNTHESIS IN FIVE-DAY SEEDLINGS. (EXPERIMENTS USING VITAMIN $B_1$ FRAGMENTS). Kulesha, Ya.; Moshchinskii, P. (Lodzinsk Tech. Inst., Poland). Radiobiologiya, 8: 888-92(1968). (In Russian).

Preplanting irradiation of wheat seeds with the $\gamma$ rays of $^{60}$Co does not suppress thiamine biosynthesis, but even intensifies it, especially when comparatively large doses (10 to 20 krad), which produce a lag in plant growth, are used. An increase in the concentration of pyrimidine and thiazole fragments of thiamine in the nutrient solution does not produce a proportionate increase in the content of this vitamin in the seedlings. One thiamine fragment (either pyrimidine or thiazole) in the nutrient solution is sufficient to intensify thiamine biosynthesis by young plants; moreover, all the thiamine formed is phosphorylated, since it is absent in the free form. (JPRS)

**17943** RADIATION DISTURBANCES OF NUCLEIC ACID METABOLISM AT VARIOUS PHASES OF ONTOGENESIS OF WHEAT GROWN FROM IRRADIATED SEEDS. Chopyak, A. M.; Budnitskaya, E. V.; Stoletov, V. N. (Inst. of Biochemistry, Moscow. Moscow State Univ.). Radiobiologiya, 8: 893-9(1968). (In Russian).

It was shown that in the ontogenesis of wheat of the Krasnozernaya variety under the influence of 5 and 10 kR of $\gamma$ irradiation of the seeds, there are substantial changes in the content of DNA, RNA, and protein depending on the irradiation dose. The disruptions are sharply manifested during heading, blooming of the plants, and during ripening of the seeds of the new generation. Changes in the DNA and RNA content, produced by irradiation of seeds at a dose of 5 kR, in the embryos of the seeds of the new generation of wheat are irreversible. Irradiation at a dose of 10 kR produces a change in the DNA content in the embryos of seeds of the new generation of nonvernalized wheat. Under the influence of irradiation of seeds during ontogenesis of wheat, there is an uncoupling of the relationship of nucleic acid and protein biosynthesis, as well as a disruption of the relationship of nucleic acid biosynthesis and that of the phosphorus-containing compounds of the acid-soluble fraction. (JPRS)

**17944** INFLUENCE OF X-RAYS ON THE GROWTH-STIMULATING PROPERTIES OF AN EXTRACT FROM THE LIVER OF AN ADULT HEN. Machablishvili, Sh. P. (Georgian Zootechnical-Veterinary Educational and Research Inst., Tbilisi, USSR). Radiobiologiya, 8: 921-3(1968). (In Russian).

The component of an extract from the liver of an adult hen, which stimulates growth of the liver in chick embryos, is characterized by low resistance and is decomposed when the extract is subjected to x-irradiation within the dose range of 4000 to 6000 R. An extract irradiated at a dose of 6000 R produces an inhibition of normal growth of the liver in chick embryo recipients. (JPRS)

**17945** DEPENDENCE OF THE DEPOSITION OF RADIOBARIUM AND RADIOYTTRIUM IN THE SKELETON OF ANIMALS ON THE CALCIUM LEVEL IN THE DIET. Dubrovina, Z. V.; Pogodin, R. I. (Inst. of Biophysics, Moscow). Radiobiologiya, 8: 927-9(1968). (In Russian).

Considerations are cited on the possible mechanism of the protective effect of Ca against the sorption by the bone of a number of osteotropic cations, capable of ion-exchange with the Ca of the bone. According to the law of mass action, the level of Ca entering the blood should influence the deposition in the skeleton not only of Sr, but also of other cations. Two short-term experiments on rats, in which the retention of $^{140}$Ba and $^{91}$Y in the skeleton was determined in the presence of eight diets with different Ca contents, are described. A relationship between the activity of the skeleton and the level of Ca intake, which are described by exponential functions with close exponents, was observed. (JPRS)

**17946** STUDY OF THE ACTIVITY OF CERTAIN ENZYMES OF THE LIVER LYSOSOMES OF IRRADIATED ANIMALS. Arkhipov, A. S.; Sakayan, E. S.; Kozlov, Yu. P. (Moscow State Univ.). Radiobiologiya, 8: 915-17(1968). (In Russian).

Whole-body x irradiation produced an increase in the free cathespin, acid phosphatase, and acid ribonuclease activity, of liver homogenates of rats, which depended on the dose of irradiation and was apparently caused by damage to the lysosome membranes. The free acid phosphatase and cathepsin activity increased immediately after irradiation of the animals. The maximum increase in the free enzyme activity after irradiation of the animals at a dose of 700 R was observed on the fifth to sixth day. (JPRS)

**17947** STATE OF THE RED BLOOD CELLS AND HEMODYNAMICS IN THE CASE OF INHALATION OF AMMONIUM PLUTONIUM PENTACARBONATE BY RATS. Kalmykova, Z. I. (Inst. of Biophysics, Moscow). Radiobiologiya, 8: 925-7(1968). (In Russian).

It was shown on 317 rats of the Wistar line that in the case of a single inhalation of ammonium plutonium pentacarbonate, with the deposition of 0.024 to 0.032 $\mu$Ci of plutonium-239 in the lungs, hypoxemia, accompanied by hypervolemia and acceleration of blood flow, periodically arises; in the case of chronic inhalation, during the late periods 18 to 20% erythrocytes with an increased acid resistance appear in the blood. (JPRS)

**17948** IDENTIFICATION OF CHIMERISM OF GUINEA PIGS. Kaulen, D. R.; Tatushina, M. A. (Inst. of Epidemiology and Mi-

crobiology, Moscow). Radiobiologiya, 8: 838-42(1968). (In Russian).

The chimerism of guinea pigs γ irradiated at a dose of 625 R and treated by transplantation of homologous bone marrow was investigated. The donor cells were identified in the organism of the recipient by the method of karyotypic analysis of the bone marrow of radiochimeras, when females were used as the donors and males as the recipients. During a period of two to three months after the radiation influence, 40% of the irradiated male guinea pigs, treated by transplantation of bone marrow cells ($150 \cdot 10^6$ cells of a female), survived. In the period from 12 days up to six months after irradiation and transplantation of hematogenic tissue, in 92% of the cases the chimerism was incomplete with an average content of donor cells of about 60%. No pronounced signs of immunological conflict were noted, although this was established in experiments on mice according to secondary sickness, which indicates the development of mutual tolerance of the donor and recipient cells. A comparative analysis indicated that the immunological reactivity of radiation chimeras a month after radiation is caused by functioning of the donor cells. (JPRS)

**17949** STATE OF AUTOINFECTIOUS RESISTANCE IN MICE TREATED WITH TRITIUM OXIDE. Shal'nova, G. A.; Zhuravlev, V. F.; Kuz'mina, T. D. (Inst. of Biophysics, Moscow). Radiobiologiya, 8: 872-5(1968). (In Russian).

The influence of a single intraperitoneal injection of tritium oxide (0.3, 0.15, and 0.08 mCi/g) was studied in experiments on 104 mice. Acute radiation sickness, accompanied by a drop in weight and disturbances of the hematological indexes, developed in the mice. Among the treated mice, the number of enteric bacteria, most of which are hemolytic, was increased in comparison with intact mice. In addition, generalization of endogenous infection (the appearance of enteric bacteria in the internal organs) was observed. (JPRS)

**17950** INFLUENCE OF RADIOTOXINS FROM THE LIVERS OF RATS SUBJECTED TO γ IRRADIATION ON THE SUBSTRATE AND HORMONAL INDUCTION OF TRYPTOPHAN PYRROLASE. Mel'nikova, S. K.; Lebedeva, N. E.; Kuzin, A. M. (Inst. of Biological Physics, Pushchino on the Oka, USSR). Radiobiologiya, 8: 880-2(1968). (In Russian).

The influence of the toxic products accumulated in the liver of rats during γ irradiation on the substrate and hormonal induction of tryptophan pyrrolase was investigated. It was shown that the inhibition of the adaptive response of rats to the administration of tryptophan four days after the injection of radiotoxins reaches about 60% and is restored by the eighth day. Analogous inhibition of substrate induction during the same periods is produced by whole-body γ irradiation at a dose of 500 R. The enzyme activation induced by hydrocortisone is not inhibited by radiotoxins, as well as by direct irradiation of the animals at a dose of 1000 R. It is proposed that the toxic products formed during γ irradiation play an important role in the radiation disruption of substrate induction of tryptophan pyrrolase. (JPRS)

**17951** INFLUENCE OF IRRADIATION ON THE EXCRETION OF DEOXCYTIDINE AND THYMIDINE IN MONKEYS. Tereshchenko, O. Ya.; Tarakanova, M. P. (Inst. of Biophysics, Moscow). Radiobiologiya, 8: 863-6(1968). (In Russian).

For a further test of the mechanisms of postradiation destruction of radiosensitive tissues, as well as the development of diagnostic tests, it is important to know the principles of the postradiation excretion of deoxynucleosides in man and other primates. This work presents the corresponding information, obtained on 14 Maccaca rhesus monkeys. It was established that in normal Maccaca rhesus monkeys, the urine contains deoxycytidine (≈0.09 μg/ml) and thymidine (≈0.04 μg/ml). On the first day after whole-body γ irradiation of the monkeys at the minimum absolute lethal dose, the excretion of both nucleosides is increased by a maximum of two- to four-fold. The increased excretion of nucleosides is maintained for several days after irradiation. The administration of the radiomimetic cyclophosphane (0.066 g/kg of body weight) also produces increased excretion of deoxycytidine. (JPRS)

**17952** EARLY DISTURBANCES OF PROTEIN BIOSYNTHESIS IN ACUTE RADIATION SICKNESS. D'yachenko, A. G. (Scientific Research Inst. of Medical Radiology, Kharkov). Radiobiologiya, 8: 796-9(1968). (In Russian).

The incorporation of a $^{14}C$-protein hydrolyzate of Chlorella into microsomes (DOC-soluble and insoluble proteins), the pH 5 enzymes, the residual proteins of the cell fluid, and aminoacyl-tRNA of the liver and spleen of white rats was investigated 2, 6, 12, and 24 hr after x irradiation; the kinetics of incorporation of a label into the indicated protein fractions 12 hrs after irradiation was also studied. A substantial disturbance of protein biosynthesis as a result of irradiation was established; moreover, a significant inhibition of synthesis was noted in the spleen, whereas in the liver the direction of the changes depended on the phase of radiation sickness, although, on the whole, activation of protein synthesis in this organ could be noted during the first 24 hrs after irradiation. (JPRS)

**17953** THE ROLE OF SINGLE CLEAVAGES IN THE MECHANISM OF THE ACTION OF IONIZING RADIATION ON SUPERMOLECULAR DNA IN THE CELL. Struchkov, V. A.; Strazhevskaya, N. B. (Inst. of Biological Physics, Pushchino on the Oka, USSR). Radiobiologiya, 8: 787-95(1968). (In Russian).

The analogous nature of the dose curves of the variation of the elastoviscous properties of supermolecular DNA and the intrinsic viscosity of molecular DNA permits us to consider that the mechanism of γ radiation damage to supermolecular DNA is based upon latent damages (single cleavages) in the polynucleotide chain of the DNA macromolecules comprising these structures. A study of the quantitative principles of the formation of single cleavages made it possible to show that the radiosensitivity of DNA in the irradiation of loach sperm and T2 phage is 50 and 100 times lower, respectively, than in the case of irradiation of dilute solutions. The data obtained permitted a comparison of the radiosensitivities of two genomes of different complexity, those of phage T2 and loach sperm, and made it possible to consider the peculiarities of the organization of the genome of the cell of higher organisms. (JPRS)

**17954** EFFECTS OF CHEMICAL PROTECTORS AND ETHYLENIMINE ON THE SURVIVAL OF BACTERIA AND THE ELASTOVISCOUS PROPERTIES OF DNA ISOLATED FROM IRRADIATED BACTERIA. Shekhtman, Ya. L.; Breiksh, I. V. (Inst. of Biological Physics, Pushchino on the Oka, USSR). Radiobiologiya, 8: 806-10(1968). (In Russian).

Thanks to the use of a mild phenol method of isolating DNA, a correspondence between the survival of bacteria and the change in the elastoviscous properties of DNA after irradiation of bacteria in the presence of various chemical protectors, cystaphos, inositol, glycerin, alcohol, and glucose, as well as under the action of an alkylating agent, ethylenimine, was successfully demonstrated. (JPRS)

**17955** STUDY ON THE CEREBRAL BLOOD FLOW AND ITS MEASURING METHOD, EMPLOYING A RADIOACTIVE MEDICAL SUBSTANCE. 1. A CONSIDERATION ON THE METHOD OF MEASURING A CEREBRAL BLOOD FLOW WITH $^{131}I$-IHSA. Gondaira, Tatsujiro (Tokyo Univ.). Kaku Igaku, 3: 171-6 (Sept. 1966). (In Japanese).

A method for measuring rapid changes in cerebral blood flow was described. In this method $^{131}I$-IHSA was rapidly injected into an internal carotid artery and a dilution curve in the brain was recorded from outside the body, in order to measure a relative fluctuation in the cerebral blood flow. It was shown that there was need to correct for a fluctuation in the cerebral blood flow in the calculations. The method was also carried out simultaneously with the $N_2O$ method; and the fluctuation in the cerebral blood flow, owing to the load by $CO_2$ or $O_2$, was measured by both methods. The results obtained agreed well with those by the $N_2O$ method. (NSA of Japan)

**17956** EFFECT OF γ IRRADIATION ON THE STRUCTURE OF NUCLEIC ACID. II. CHANGE OF DEOXYRIBONUCLEIC ACID. Kubota, Minoru; Watanabe, Etuo (Tokyo Univ. of Fisheries). Nippon Suisan Gakkaishi, 33: 775-81(Aug. 1967).

The effect of γ irradiation on the structure of deoxyribonucleic acids (DNA) prepared from milts of several fishes; skipjack, mackerel, sea bream, and three-lined grunt was studied. Aqueous solutions of the DNAs were irradiated in the presence of air, and examined for changes by measurements of ultraviolet absorption spectra, viscosity, specific rotation, and the amounts of ammonia formed and phosphate liberated. Results obtained were summarized as follows: Hyperchromisity in ultraviolet absorption spectrum was observed when the solutions of DNAs were irradiated with doses of $5 \times 10^3$ R and $10^4$ R. On irradiating with doses above $5 \times 10^3$ R, the amounts of ammonia formed and phosphate liberated from DNA increased, gradually in the former, and abruptly in the latter. Viscosity and specific rotation of DNA solution dropped to near zero on irradiation with doses above $5 \times 10^3$ R, irrespective of the fish species. Skipjack DNA showed a sharp peak in sedimentation pattern. However, on irradiating with a dose of $10^3$ R, the peak turned somewhat broader. From these results, together with those in the previous paper, the effect of γ irradiation on fish DNA could be concluded as follows: On irradiating with a dose of $5 \times 10^4$ R, fish DNA began to suffer partial scission of the main molecular chain and the breakdown of the hydrogen bonds contributing to maintain the helical structure. On irradiating with a dose of $10^5$ R, the DNA underwent further scission and breakdown in intra- and intermolecular regions. On irradiating with about the same dose, some components, base ring and ribose, of the DNA,

seemed to be broken successively after the scission of ester and glycosidic linkages. (NSA of Japan)

**17957** CHANGES IN THE PROTEIN TRANSPORT FROM MICROSOMES INTO MITOCHONDRIA DURING ACUTE RADIATION DAMAGE OF THE ORGANISM. Galkin, A. P.; Piskareva, E. V.; Diachenko, A. G.; Paskevich, I. F.; Todorov, I. N. (Scientific Research Inst. of Radiology, Kharkov). Biokhimiya, 33: 981-92 (Sept.-Oct. 1968). (In Russian).

The effect of whole-body irradiation on the transport of proteins from microsomes to mitochondria was studied in vitro employing labeled systems ($^{14}$C-tagged microsomes + cell sap + mitochondria) obtained from the liver of normal and irradiated rats. Radioinduced inhibition of the transport reaction was observed. This inhibition was associated with anomalies of cell sap of irradiated animals; these disturbances are also influenced to some extent, however, by radiation changes in microsomes and mitochondria. Chromatographic separation of in vivo $^{14}$C-labeled water- and phosphate buffer-soluble proteins of DEAE-cellulose, and also DEAE-cellulose and CM-cellulose purification of the cytochrome c fraction from mitochondria of liver and spleen of normal and irradiated rats indicated significant decrease in radioactivity of the proteins of these fractions separated by chromatography. There was also a decrease in specific radioactivity of water-soluble proteins in the zone of localization of hexokinase, DNase, and RNase, with a parallel decrease in the enzyme activity of the last 2 enzymes in the fraction from irradiated animals. It is suggested that irradiation results in disturbances in the transport of various proteins from microsomes to mitochondria in vivo. (BBB)

**17958** EXPERIMENTAL STUDIES ON THE EFFECT OF $^{95}$Zr–$^{95}$Nb IN ALBINO RATS. I. DISTRIBUTION OF $^{95}$Zr–$^{95}$Nb AMONG ORGANS AND AUTORADIOGRAPHY OF TIBIA FROM SUBCUTANEOUSLY INJECTED ALBINO RATS. Morishige, Toshiko (Kyushu Univ., Fukuoka). Nippon Eiseigaku Zasshi, 21: 306-12 (Oct. 1966). (In Japanese).

As previously reported, $^{95}$Zr–$^{95}$Nb was detected in fallout and vegetation as a consequence of nuclear explosions. To study the biological effect of $^{95}$Zr–$^{95}$Nb, the radioactive material was injected subcutaneously in rats, which were sacrificed at 5 hr, 24 hr, 7 days, 14 days, 28 days, and 63 days later. Distribution of $^{95}$Zr–$^{95}$Nb in the main organs and tissues was determined and the radioactivity in urine and feces. Autoradiographs of tibia were made by the macro-contact method to observe localization and turnover of $^{95}$Zr–$^{95}$Nb in the tibia. The $^{95}$Zr–$^{95}$Nb was detected in larger amounts in the tibia than in other organs and tissues. The next highly radioactive tissue was upper incisor, but radioactivities in most organs except tibia were approximately at same level on the 63rd experimental day because of biological turnover and excretion. Amounts of $^{95}$Zr–$^{95}$Nb in both urine and feces were highest within 24 hr after injection. After that, the amounts of $^{95}$Zr–$^{95}$Nb excreted in urine and feces per 24 hr gradually decreased and then remained at about same level from the 14th experimental day to the end of the experiment. Their excretion was generally greater in urine than in feces throughout the experimental period. Results of the autoradiographic study of the tibia showed that $^{95}$Zr–$^{95}$Nb is markedly deposited in the metaphysis close to the epiphyseal line in the initial stage (up to the 5th experimental day) and consequently accumulated in metaphysis rather than epiphysis and diaphysis. On the 14th experimental day it is released from the metaphysis near the epiphyseal line but depositions in the epiphysis did not disappear. By the 63rd experimental day deposits in the epiphysis were still evident. (BBB)

**17959** RADIOIODINE STUDIES ON PROLACTIN ACTION IN TADPOLES. Gona, Amos G. (New Jersey Coll. of Medicine and Dentistry, Jersey City). Gen. Comp. Endocrinol., 11: 278-83 (Oct. 1968).

Prometamorphic stages of Rana pipiens and R. catesbeiana tadpoles treated intraperitoneally with ovine prolactin showed significantly lower thyroidal $^{131}$I uptake and lower serum PB$^{131}$I (protein-bound iodine) than closely matched, saline-injected controls. In climax tadpoles the thyroidal $^{131}$I uptake was not affected by prolactin. However, the conversion ratio and thyroid-serum ratio were both reduced by prolactin. Paper chromatography of thyroid hydrolyzates showed that prolactin does not block organification of $^{131}$I in the thyroid. Serum PB$^{131}$I of the prolactin-treated climax tadpoles was not lower than that of the controls despite the inhibition of metamorphosis. It was concluded that prolactin interferes with the thyroidal iodide-trapping mechanism in tadpoles, and also that some degree of peripheral action is involved. (BBB)

**17960** EFFECT OF γ IRRADIATION ON THE STRUCTURE OF NUCLEIC ACID. I. CHANGE OF COMPONENTS OF NUCLEIC ACID. Kubota, Minoru; Watanabe, Etuo (Tokyo Univ. of Fisheries). Nippon Suisan Gakkaishi, 33: 769-74 (Aug. 1967).

The effect of γ irradiation on the constituent components of nucleic acid was examined as the first step for studying the effect of γ irradiation on its structure. In the present study, nucleic acid bases, nucleosides, nucleotides, and ribose, were γ irradiated mostly in aqueous solution and in the presence of air, and the irradiation effects on those substances were examined by measuring the change in ultraviolet absorption spectrum and the amounts of ammonia formed and ribose, phosphate, bases, and nucleosides liberated. Results obtained were as follows: Ammonia was formed when solutions of bases, nucleosides, and nucleotides were irradiated with doses above $10^5$ R. On irradiating with doses above $10^6$ R, bases and ribose were liberated from nucleosides. However, from nucleotides, corresponding nucleosides and ribose were not liberated, but bases and ribose-5-phosphate were liberated. By irradiation with a dose of $2 \times 10^6$ R, 70% of ribose was decomposed. From these results it could be concluded that with γ irradiation with doses above $10^6$ R, the nucleotide was affected in several ways, namely, deamination, scission of glycosidic bond between sugar and base and of ester bond between sugar and phosphate, and destruction of base ring. (NSA of Japan)

## Ecology

*Refer also to abstracts 17999, 18008, 18011, 18016, and 18138.*

**17961** (AEC-tr-7030, pp 49-64) MECHANISMS OF RADIOECOLOGICAL CONCENTRATION PROCESSES IN SEAS AND OCEANS. Polikarpov, G. G. Translation of report A-AC-82/G/L-1247.

The mechanisms of absorption and accumulation of radioisotopes by aquatic organisms from the carriers in the water medium are discussed. The importance of the food chain in migration of radioisotopes through the environment is pointed out. A discussion is presented of the significance of accumulation coefficients of radioisotopes in closely related species occurring in different seas and oceans for extrapolation of data on radioactivity of the organisms or of the medium. Tables are presented to show concentrations of $^{144}$Ce, $^{54}$Mn, $^{106}$Ru, and $^{90}$Sr in Sargassum natans and coefficients of accumulation of $^{144}$Ce, $^{137}$Cs, $^{106}$Ru, and $^{90}$Sr in larvae and adults of the crab, Planes minutus. Radioecological studies on fishes, mammals, seaweeds, and plankton from various regions of the Pacific, Atlantic, and Indian Oceans are reported. Radioecological surveys of the southern seas of the Soviet Union are described. Studies on coefficients of accumulation and isotopic mixing in the flora and fauna of the Black Sea are reported. Cytogenetic studies were conducted on fish of the Black Sea. (H.L.W.)

**17962** (AECL-3184) OCCURRENCE AND DISTRIBUTION OF SMALL MAMMALS IN THE WNRE CONTROLLED AREA, PINAWA, MANITOBA. Adam, Marie; Iverson, Stuart L. (Atomic Energy of Canada Ltd., Pinawa (Manitoba). Whiteshell Nuclear Research Establishment). Nov. 1968. 32p. Dep. CFSTI. CAN $1.00.

Small mammals were snap-trapped during the summer of 1967 in the major habitats present within the Whiteshell Nuclear Research Establishment Controlled Area. This area, about 75 miles northeast of Winnipeg, is located in the ecotone between the boreal forest and the prairies. Parts of the mammalian fauna of both areas are present although the predominant influence appears to be the boreal forest. Peromyscus maniculatus and Clethrionomys gapperi were most common in the forested areas while Microtus pennsylvanicus was most common in the grasslands. (auth)

**17963** (CONF-670503) SYMPOSIUM ON RADIOECOLOGY. PROCEEDINGS OF THE SECOND NATIONAL SYMPOSIUM HELD AT ANN ARBOR, MICHIGAN, MAY 15-17, 1967. Nelson, Daniel J.; Evans, Francis C. (eds.) (Division of Biology and Medicine (AEC), Washington, D. C. Ecological Society of America. Michigan Univ., Ann Arbor). Mar. 1969. 783p. Dep. CFSTI.

Separate abstracts were prepared for 58 papers. In addition, there were 31 other papers, 27 of which had previously been abstracted in NSA, and five papers on metabolism of elements. (C.O.)

*For abstracts of individual papers see: 17894–17908, 17964–17985, 18005–18017, 18040, 18088–18091, and 18127–18129.*

**17964** (CONF-670503-, pp 1-8) THE SCIENTIST'S RESPONSIBILITY IN THE CONTROL OF MAN'S ENVIRONMENT. Holifield, Chet (Joint Committee on Atomic Energy (U. S. Congress)).

The role of atomic energy in scientific urban planning is discussed with particular emphasis on control of environmental pollution. (M.M.B.)

**17965** (CONF-670503-, pp 32-8) IMPLICATIONS OF RADIOECOLOGY FOR OTHER RESEARCH IN ENVIRONMENTAL CONTAMINATION. Hayne, Don W. (North Carolina State Univ., Raleigh. Inst. of Statistics).

The general problems encountered in environmental effects of pesticides are found to be similar to the problems that concern radioecologists. These are: distribution and occurrence of contaminants, including the background problem; kinetics of contaminants in the ecosystem, including cycling and use of tracers in studies of cells or populations; responses of the individual to exposure, including injuries; and effects on growth, survival and reproduction, development of resistance, and populations. (M.M.B.)

**17966** (CONF-670503–, pp 53-60) ECOLOGY OF TWO POPULATIONS OF AN AQUATIC ISOPOD (LIRCEUS FONTINALIS RAF.), WITH EMPHASIS ON IONIZING RADIATION EFFECTS. Styron, C. E. (Emory Univ., Atlanta, Ga. Dept. of Biology).

Two populations of Lirceus fontinalis Rafinesque in DeKalb County, Georgia, are isolated from each other in separate river drainages and are evolving in response to different environmental stresses. The background radiation count from naturally occurring radionuclides in the granite at Mount Arabia is several times above the average for terrestrial ecosystems. Drought and high temperatures appear to be the main ecological factors limiting the population on Mount Arabia. These factors are of little moment to the population in Lullwater Creek where biotic factors are of primary ecological significance to the Lirceus population. There is a significant increase in tolerance to gamma radiation and drought stress with age in Mount Arabia Lirceus. Mount Arabia Lirceus are 7.88 times more tolerant to ionizing radiation stress and are 5.36 times more tolerant to drought stress than Lullwater Creek Lirceus. (auth)

**17967** (CONF-670503–, pp 68-77) EFFECTS OF GAMMA IRRADIATION ON POPULATIONS OF SOIL INVERTEBRATES. Edwards, C. A. (Purdue Univ., Lafayette, Ind. Dept. of Entomology).

Invertebrate animals living in soil or on moist plaster of Paris were irradiated with gamma rays from a cobalt source. Soil samples and cultures were adequately replicated and radiation doses ranged from 10 Krads through 25, 50, 100, and 200 Krads. The animals in culture included representative Oligochaeta, Myriapoda, Acarina, Collembola, and Insecta. Susceptibility to radiation varied greatly both between and within groups. Oribatid mites were most resistant, surviving up to 80 days after exposure to 200 Krads; and isopods, which were most susceptible, were all dead 60 days after exposure to 10 Krads. There was excellent correlation between activity and susceptibility to radiation. Mortality/time curves were not linear even on a probit scale but were usually distinguishable into an initial steep curve and a shallow secondary one. Radiation dosages were positively correlated with percentage mortalities but not in a simple logarithmic or probit relationship. Populations of all main groups of invertebrates in soil samples were regularly counted for three months after irradiation. Most decreased in numbers sigmoidally with time, but a few species eventually multiplied after a small dose of radiation, probably due to greater susceptibility of predator than prey. Animals were usually more susceptible to irradiation in cultures than in soil. (auth)

**17968** (CONF-670503–, pp 88-98) RECOVERY OF A TROPICAL RAIN FOREST AFTER GAMMA IRRADIATION. Jordan, Carl F. (Puerto Rico Nuclear Center, Rio Piedras).

Recovery of vascular vegetation in a tropical rain forest irradiated with a 10,000 Ci $^{137}Cs$ source was compared to recovery after mechanical stripping and herbicide treatment. Minor differences in vegetation quality, quantity, and species diversity occurred between areas, but most of these differences could be accounted for by factors other than gamma radiation. The only difference that was uniquely a radiation response was sprouting of trees near their bases where they were shielded from radiation. Recovery of a tropical rain forest damaged by gamma radiation closely resembles secondary succession following other types of disturbances in a tropical rain forest of Puerto Rico. (auth)

**17969** (CONF-670503–, pp 99-109) COMPOSITIONAL CHANGES OF ECOSYSTEMS DURING CHRONIC GAMMA IRRADIATION. Garrett, Arthur (Emory Univ., Atlanta, Ga. Dept. of Biology).

A series of observations were made on segments of granite outcrop ecosystems during chronic $\gamma$ irradiation. The number of individuals in each species found in samples of the plant and soil arthropod community components were counted at ten dates during a fourteen month period. Dose rates covered the interval from 161 to 0.1 R/hr for total doses ranging between 1356 and 0.8 kR. The values of the index of similarity and ten diversity indexes are presented as annual progressions or in terms of their regression on radiation exposure and elapsed time. In general, the index of similarity and all diversity indexes declined with increasing radiation exposure. Similarity considerations seem the more informative regarding vegetational changes. Diversity indexes seem more appropriate to describing changes in soil arthropod samples. The indexes are useful as concise descriptive statements of change in taxonomic composition of ecosystems. (auth)

**17970** (CONF-670503–, pp 166-72) RESPONSE OF RODENTS TO ACUTE GAMMA RADIATION UNDER FIELD CONDITIONS. Golley, Frank B.; Gentry, John B. (Savannah River Ecology Lab., Aiken, S. C.).

The response of two species of wild rodents to acute $\gamma$ radiation under field conditions was studied. Old-field mice (Peromyscus polionotus) and house mice (Mus musculus) were released in two acre enclosures and after a four week period for establishment of the population, were retrapped and irradiated at the $LD_{50/30}$ established in the laboratory. Mus survived at the same rate as in the laboratory; Peromyscus survived at a substantially lower rate in the field. The frequency of capture, extent of movement within the enclosure, the time sequence of death and change in body weight supported the observations on survival rate. (auth)

**17971** (CONF-670503–, pp 221-5) STRONTIUM–CALCIUM RELATIONSHIPS IN AQUATIC FOOD CHAINS. Ophel, I. L.; Judd, J. M. (Atomic Energy of Canada Ltd., Chalk River (Ontario)).

Different species of fish from the same lake were found to have marked differences in stable strontium content. The same species in different lakes contain significantly different amounts of this element. No corresponding variation in calcium contents was found. Food organisms in the lakes have marked differences in strontium and calcium content and Sr/Ca ratios. Analyses of stomach contents indicate a correlation between Sr/Ca ratios in food and those in fish. It appears that differences in stable strontium (and radiostrontium) content among fish are dependent on feeding habits of the species. (auth)

**17972** (CONF-670503–, pp 234-9) RADIOACTIVE AND STABLE STRONTIUM ANALYSIS OF UPPER MISSISSIPPI RIVER CLAMSHELLS. Pahl, George (Saint Mary's Coll., Winona, Minn. Dept. of Biology).

The freshwater clam forms a significant portion of the benthic fauna of the Upper Mississippi River biological community. Evidence indicates that it may serve as an ideal biological monitor of the $^{90}Sr$ concentration not only in the Upper Mississippi River but also of the worldwide fallout of this radionuclide. Advantage was taken of the fact that the shells of the long-lived clams of this area are composed of distinct annual layers and chemically are composed almost exclusively of calcium and/or strontium carbonate. The shells of live clams of the genus Lampsilis collected at the end of the 1962–4 growing seasons were analyzed for both stable and radioactive strontium. Shell layers formed over the ten-year period of 1955–64 showed stable strontium to be consistently 10 orders of magnitude greater than that of radioactive strontium. During this time the stable strontium increased by a factor of only 2, while the $^{90}Sr$ increased by a factor of 7. This rise of radiostrontium over the 1955 to 1964 period, while not corresponding with the overall strontium increase, did correlate closely with the fallout pattern associated with nuclear weapon testing carried out during this period. (auth)

**17973** (CONF-670503–, pp 249-57) $^{137}Cs$ IN FRESHWATER FISH DURING 1954–1965. Gustafson, Philip F. (Division of Biology and Medicine (AEC), Washington, D. C.).

Concentrations of $^{137}Cs$ from worldwide fallout have been determined in samples of small perch and walleyes preserved in alcohol taken from Red Lakes, Minnesota, during 1954 through 1965. Measurements were made on bulk samples by means of gammaray spectrometry. Collections of fish made each year during the month of July, from near the same location within the lake, were provided by Professor Lloyd Smith of the University of Minnesota. The deposition rate and the total accumulation of $^{137}Cs$ in the Red Lakes area were derived from data obtained elsewhere in the region by making corrections for differences in local precipitation. The $^{137}Cs$ levels observed in fish changed fairly rapidly in response to changes in fallout rate; however, there was a substantial contribution from the accumulated deposition of this radionuclide in the aquatic ecosystem which acts as a sink for this radionuclide. Solution of a mathematical expression relating the concentration of $^{137}Cs$ in fish to the total amount of $^{137}Cs$ present in the lake, and its rate of deposition, indicated 25 to 80% of that found in fish came from the long-term accumulation. This accumulation was the more important source for $^{137}Cs$ uptake by fish during times of low fallout rate. The highest concentration in fish was ~600 pCi/kg seen during 1963; by 1966 it had decreased to ~250 pCi/kg. The effective half-time for $^{137}Cs$ in the lake system, as inferred from the small fish, was ~2½ years. The persistence of $^{137}Cs$ in a freshwater system is in sharp contrast to the behavior of terrestrial levels. The continuing availability of $^{137}Cs$ to freshwater fish suggests that they will provide an important source of dietary $^{137}Cs$, for some time, for persons who depend on them for food. (auth)

**17974** (CONF-670503–, pp 270-7) THE ROLE OF TUBIFICID WORMS IN THE TRANSFER OF RADIOACTIVE PHOSPHOROUS IN AN AQUATIC ECOSYSTEM. Whitten, Bert K.; Goodnight, Clarence J. (Western Michigan Univ., Kalamazoo).

The accumulation of radiophosphorous by tubificid worms from water, bacteria, and sediment was studied. Tubificid worms took up more phosphorous from water and bacteria than from sediment. These worms were able to accumulate phosphorous from both soluble and organic particulate sources. Radioautographs demonstrated that much of the activity was in the tissues of these worms and not simply adsorbed. No significant accumulation from radioactive orthophosphate that was adsorbed onto sterile sediments was observed. Bluegills and bluntnose minnows fed tubificid worms labeled with radiophosphorus accumulated radiophosphorus in their tissues. Theoretical calculations based on these feeding studies demonstrated that an equilibrium was approached after two weeks in the tissues of these fish and was maintained through the duration of the experiment. Tubificid worms, because of their abundance in some aquatic ecosystems may have an important part in the transfer of radioactive phosphorus from water and detritus to other components of the aquatic ecosystem such as fish. These worms appear to function in conjunction with bacteria in the recycling of radioactive phosphorus from detritus and sediments. (auth)

**17975** (CONF-670503–, pp 278-84) TRACER EXPERIMENT WITH $^{131}I$ IN AN OLIGOTROPHIC LAKE. Kolehmainen, S.; Takatalo, S.; Miettinen, J. K. (Helsinki Univ. (Finland). Dept. of Radiochemistry).

A tracer experiment with $^{131}I$ in a natural oligotrophic lake was carried out to provide quantitative information on the distribution of this important fallout nuclide in all components of a natural ecosystem. Seventeen mCi of $^{131}I$ were pumped from a moving boat and efficiently mixed within 1 hr 40 min into the lake of 23,000 $m^3$. Samples of water, plants, a sponge and three species of fish were collected during 41 days. The results showed that peak radioactivity was reached in all organisms: algae, water plants, a sponge (Spongilla lacustris) and fish, crucian carp (Cyprinus carassius), perch (Perca fluviatilis) and rainbow trout (Salmo gairdneri), within five to seven days. The effective half-time of radioactivity in the lake water was 6.5 days, that of the added element iodine 36 days. The main factor in removing iodine from the lake water was the moss (Sphagnum) growing at the shore line. Concentration factors calculated by comparing the peak radioactivity of the organism to the initial radioactivity in the water (in nCi/kg fresh wt per nCi/l water) were: sponge 200, green algae 200, moss 90, yellow water lily (Nuphar luteum) 60, crucian carp 25. The animal species showed the longest biological half-lives for iodine. (auth)

**17976** (CONF-670503–, pp 307-18) ACCUMULATION OF $^{226}Ra$ IN TWO AQUATIC ECOSYSTEMS. Martin, Susan S.; Helm, William T.; Sigler, William F. (Utah State Univ., Logan. Dept. of Wildlife Resources).

Uranium ore processing mills often discharge wastes, sometimes including $^{226}Ra$, into rivers. The accumulation of $^{226}Ra$ in portions of two southwestern Colorado rivers was measured. The lower Animas River, formerly damaged by wastes from a uranium mill at Durango, showed excellent recovery of biological populations and low levels of $^{226}Ra$ in the ecosystem. The San Miguel and Dolores River system was in poor biological condition due primarily to chemical pollution from the Uravan, Colorado, uranium mill. Samples of the biota contained increasing amounts of $^{226}Ra$ as distance below the mill increased, although $^{226}Ra$ content of the water and sediments decreased with distance. Apparently organisms could not survive sufficiently long in the upper pollution zone to accumulate the amounts of $^{226}Ra$ which might otherwise be found. (auth)

**17977** (CONF-670503–, pp 346-54) DISTRIBUTION OF RADIONUCLIDES IN THE ENVIRONMENT OF ENIWETOK AND BIKINI ATOLLS, AUGUST 1964. Welander, A. D. (Washington Univ., Seattle. Coll. of Fisheries).

Radionuclide analyses were made of more than 2000 samples of animals, plants, water, bottom sediments, and soils collected at Eniwetok and Bikini Atolls, the site of 59 nuclear tests between 1946 and 1958. Cobalt-60 was found in all samples but was dominant in the marine environment. Cesium-137 and $^{90}Sr$, however, were predominant in the land environment. All samples contained traces of $^{54}Mn$, although there were slightly larger amounts of this radionuclide in land plants and land invertebrates. Ruthenium-106 and $^{125}Sb$ were detected in significant amounts in groundwater and soil, with traces in animals and plants. Also, trace amounts of $^{207}Bi$ were found in most samples, and $^{144}Ce$ usually in algae, soils, and land plants. There were comparatively large amounts of $^{55}Fe$ in a number of samples, especially in vertebrates. Plutonium-239 was found in soil and in the skins of rats and birds in the few samples analyzed. The soils contained the highest levels of radioactivity, followed by invertebrates, groundwater, shorebirds, plants, rats, plankton, algae, fish, bottom sediments, seawater, and seabirds. (auth)

**17978** (CONF-670503–, pp 412-19) PHOSPHORUS AND ZINC CYCLES AND PRODUCTIVITY OF A SALT MARSH. Pomeroy, L. R.; Johannes, R. E.; Odum, E. P.; Roffman, B. (Georgia Univ., Athens. Dept. of Zoology).

The cycles of the elements P and Zn are described from the results of two field experiments using $^{32}P$ and $^{65}Zn$. Marsh grass (Spartina alterniflora) and sediments dominate both cycles. The uppermost meter of sediments contains enough P to support Spartina production for 500 years and enough Zn for 5000 years. Spartina production removes P and Zn from the subsurface (reduced) sediments and introduces them into the water (via bacterial utilization of dead Spartina and subsequent utilization of the bacteria by detritus feeders) at a rate that replaces total water P in a month and total water Zn in a year. A significant part of the P is exported from the marsh in organisms and detritus. The P and Zn in the estuarine water are in equilibrium with plankton, bacteria, and surface (oxidized) sediments. The equilibrium strongly favors the sediments. Probably the subsurface-sediment compartment P and Zn is replaced by the conversion of oxidized sediments to reduced sediments through the process of creek meandering. The oxidized sediments are in equilibrium with the water, which received inputs of P and Zn from both land and sea. The transfer of P and Zn from the deep sediments to the water by Spartina explains the high concentration of these elements in the water of marshy estuaries. (auth)

**17979** (CONF-670503–, pp 431-9) THE POTENTIAL IMPORTANCE OF SPARTINA ALTERNIFLORA IN CONVEYING ZINC, MANGANESE, AND IRON INTO ESTUARINE FOOD CHAINS. Williams, Richard B.; Murdoch, Marianne B. (Bureau of Commercial Fisheries, Beaufort, N. C. Radiobiological Lab.).

The potential importance of cord grass, Spartina alterniflora, in conveying radioisotopes of zinc, manganese, and iron into estuarine food chains was evaluated on the basis of its annual production, its content of the three elements, and its annual cycle of growth and decay. The growth of Spartina was studied with harvest and other techniques in salt marshes near Beaufort, N. C. Standing crop at maturity (in the fall) and annual production were estimated to average 545 and 650 g dry wt/$m^2$, or 208 and 248 g C/$m^2$, respectively. Spartina production approached one-third the total phytoplankton net production of adjacent estuaries, and was thus potentially important in estuarine food chains. Zinc, manganese, and iron all had markedly higher concentrations in dead Spartina than in live, and averaged 22, 200, and 5000 ppM (dry wt), respectively, in the dead material. The unusually high iron content of the dead material suggested that Spartina detritus may be especially important in the movement of radioisotopes of iron from water and sediment into estuarine animal populations. (auth)

**17980** (CONF-670503–, pp 535-46) CONCENTRATIONS OF THE NATURALLY OCCURRING RADIONUCLIDES $^{226}Ra$, $^{210}Pb$, AND $^{210}Po$ IN AQUATIC FAUNA. Holtzman, Richard B. (Argonne National Lab., Ill.).

The concentrations of $^{226}Ra$, $^{210}Pb$ and $^{210}Po$ were determined in hard and soft tissues of freshwater and marine fish, shellfish, seals and whales and in some of the dietary components of whales. The $^{226}Ra$ concentrations were fairly independent of the species at about 5 pCi/100 g bone ash and 0.2 pCi/100 g wet soft tissue. The concentrations of both the $^{210}Pb$ and $^{210}Po$ in a given tissue were equal to or greater than those of the parent, $^{226}Ra$. In bone from fish and seal the concentrations of the $^{210}Pb$ and $^{210}Po$ were similar to those found in human bone, about 15 pCi/100 g ash. Fish muscle contained about 0.2 pCi $^{210}Pb$/100 g wet and about 10 times this specific activity of $^{210}Po$. The activities of both of these nuclides in the soft tissues of clams, oysters and squid were higher by one order of magnitude than in fish muscle. In bone and muscle taken from a fin whale, concentrations of these nuclides were similar to those found in fish. By contrast, teeth from sperm whales had concentrations of $^{210}Pb$ one order of magnitude greater than those in bone of fin whales. The higher concentrations of $^{210}Pb$ in sperm whales seem to be correlated with those found in some of the components of the diet (copepods, euphausiids, and possibly squid). (auth)

**17981** (CONF-670503–, pp 609-15) $^{137}Cs$ AND A POPULATION OF GEORGIA WHITE-TAILED DEER. Plummer, G. L.; Pullen, T. M. Jr.; Provost, E. E. (Georgia Univ., Athens).

Two deer populations and the vegetation eaten within a National Forest were sampled; parts of each were assayed for several fallout radionuclides. That group of plant species "desired" by deer contained the same fallout isotopes, and similar quantities of each, as the group ordinarily not eaten. Nevertheless, the concentration of one isotope differed considerably among different plant species,

as well as within the same species that occupied different habitats. Crataegus, Acer, Lonicera and Quercus contained more $^{137}Cs$ than other plants. Radiocesium in 1965 samples of deer did not differ from 1966 samples within a particular forest, but deer from different ecological systems had different concentrations regardless of the age-classes collected. Tongue and kidney contained more $^{137}Cs$ than other organs; whereas lung and liver held the smallest concentrations observed; the tongue/muscle ratio approached unity during 1966 and $^{137}Cs$ in muscle apparently decreased slightly from 1965 concentrations. Strontium-90 in mandibles averaged 25 pCi/g for 1.5-year deer and 21 pCi/g for 3.5-year animals. (auth)

**17982** (CONF-670503–, pp 635-43) $^{137}Cs$ KINETICS IN TERRESTRIAL MICROCOSMS. Witkamp, Martin; Frank, Marilyn L. (Oak Ridge National Lab., Tenn.).

Transfer of $^{137}Cs$ among compartments of terrestrial microcosms was studied using microcosms of increasing complexity. By adding one compartment at a time the role of each compartment in the kinetics of such systems can be evaluated. The results show that microbes, millipedes, snails and green plants significantly affect the $^{137}Cs$ kinetics of the investigated microcosms, and that the effect of a compartment on mineral turnover relative to the mineral content of that compartment may vary by two orders of magnitude. In an eight-compartment model, initial $^{137}Cs$ dissipated from leaf litter to microflora, millipedes, snails, green plants, sand, soil organic matter and soil leachate. Millipedes and snails reached equilibria and highest concentrations within a month. In contrast there was a steady accumulation of $^{137}Cs$ in sand, soil organic matter, and soil leachate. Analog computer simulations of the $^{137}Cs$ kinetics of various systems provided new insight in pathways and rates of turnover and stressed the importance of close contact of the investigator with both the experiment and the simulations. (auth)

**17983** (CONF-670503–, pp 665-71) BIOLOGICAL TRANSPORT OF $^{65}Zn$ IN A SOUTH CAROLINA BROOMSEDGE FIELD. Williams, James E. (Georgia Univ., Athens).

Dispersion of $^{65}Zn$ in a South Carolina broomsedge field from labeled litter in mesh bags was primarily by biological transport via plant roots. Concentrations of isotope were found in plants up to 50 cm away from mesh bags, whereas leaching and other factors moved $^{65}Zn$ less than a third that distance (15 cm). Zinc-65 was concentrated in plant shoots, whereas comparatively little isotope was found in roots. Labeled materials were placed in the field in July 1965, but no isotope was found in plants until April 1966. No $^{65}Zn$ was detected in arthropods. (auth)

**17984** (CONF-670503–, pp 709-10) RADIONUCLIDE TRACER MEASUREMENT OF FOOD WEB DIVERSITY IN NATURE. Wiegert, Richard G.; Odum, Eugene P. (Georgia Univ., Athens. Inst. of Ecology).

An example of a radionuclide tracer system used to measure the diversity of the plant-primary consumer food web in simple natural ecosystem is given. Camphorweed (Heterotheca subaxillaris) and horseweed (Erigeron canadensis), the two dominant plant species on a one-year old field in South Carolina, were labeled with $^{32}P$. The subsequent transfer to the primary consumer populations was measured. Fifteen insect species showed appreciable interaction with at least one of the tagged plants. None of the 80 other species or groups of herbivores were considered important members of the web. Diagrams compare the actual results with two hypothetical models representing extremes. It was concluded that radionuclide tracers can simultaneously serve to identify the actual, as opposed to the merely possible trophic interactions, and can give quantitative value to a given pathway. It is then possible to deal with diversity in terms of network variables rather than only in terms of number of species and individuals. (C.O.)

**17985** (CONF-670503–, pp 731-9) SYSTEMS ANALYSIS OF A COUPLED COMPARTMENT MODEL FOR RADIONUCLIDE TRANSFER IN A TROPICAL ENVIRONMENT. Kaye, Stephen V.; Ball, Sydney J. (Oak Ridge National Lab., Tenn.).

The bioenvironmental feasibility study for construction of a sea-level canal in Central America with nuclear devices requires prediction of the movement of radionuclides in a tropical environment and estimation of the possible radiation doses to indigenous man. Large complex environments can be schematically simplified if represented by coupled compartment diagrams which contain critical pathways leading to man. Since actual field data are not yet available for constructing such diagrams, a preliminary diagram was constructed that has enough flexibility for future modification and necessary expansions after on-site data become available. Such preliminary diagrams are useful because they can be used for computer sensitivity analyses using frequency response techniques when linear differential equations with constant coefficients are specified in the model. The SFR-3 digital computer code was used to determine the sensitivity of the various environmental transfer coefficients of a banana plantation to the concentration of radioactivity in the bananas that would be eaten by man. This code also provides an estimate of the integrated concentration of radioactivity in bananas resulting from a fallout pulse input to the system and the magnitude and time of the peak concentration, all of which are directly related to the internal dose received by man. (auth)

**17986** (NP–17713) BIOLOGICAL MIGRATION OF RADIONUCLIDES IN FRESHWATER AND SALTWATER BASINS. Polikarpov, G. G.; Parchevskii, V. P.; Sokolova, I. A.; Timoshchuk, V. I.; Rozhanskaya, L. I.; Ryndina, D. D.; Bachurin, A. A.; Kalninya, Z. K. (Gosudarstvennyi Komitet po Ispol'zovaniyu Atomnoi Energii SSSR, Moscow). 1968. 30p. (In Russian). Dep.

$^{90}Sr$ accumulation coefficients were determined on various organisms where the Duna River empties into the Black Sea. Water samples were 100 liters in size, while the ash samples were 50 to 100 g. The strontium was carried on Fe(OH)$_3$ by precipitating with $Na_2CO_3$, and the dried samples were counted for beta particles on an end-window counter. Global fallout was the main source of $^{90}Sr$ in the open part of the Black Sea. In the Azov Sea it was shown that plankton concentrated manganese by a factor of 200 to 1300, copper by a factor of 250 to 2700, and zinc by a factor of 3000 to 12,000. Benthic organisms concentrated manganese by a factor of 700 to 16,000, copper by a factor of 500 to 3000, and zinc by a factor of 500 to 3800. Fish concentrated manganese by a factor of 30 to 400, copper by a factor of 150 to 700, and zinc by a factor of 700 to 1800. High $^{90}Sr$ accumulation coefficients were noted for living and dead brown algae with return of $^{90}Sr$ to the environment on the death of the plant. Small $^{90}Sr$ accumulation coefficients are characteristic for red and green algae, and for flowering plants. (TTT)

**17987** (NP–17714) REGULARITIES IN RADIOECOLOGICAL CONCENTRATION PROCESSES IN SEAS AND OCEANS. Polikarpov, G. G. (Gosudarstvennyi Komitet po Ispol'zovaniyu Atomnoi Energii SSSR, Moscow). 1968. 18p. (In Russian). Dep.

An attempt is made to formulate general rules of behavior and trial generalizations with respect to accumulation coefficients of radionuclides in sea and freshwater plants. In general the accumulation coefficients of the radionuclide in seawater will be proportional to those in water. Nonisotopic carriers decrease the accumulation coefficient of a radionuclide in water plants. The accumulation coefficient (AC) varies with the state and form of the chemical element in solution. The AC value for plants are the same for similar forms of plant life, even though the salinity varies from 17 to 35‰. Accumulation coefficients (AC) for $^{137}Cs$, $^{90}Sr$, $^{144}Ce$, and $^{106}Ru$ are given for green, brown and red seaweeds, and for other types of plants. It has been shown that stable strontium can replace radioactive strontium in a plant. Work on accumulation coefficients of 20 radionuclides and on chromosomal typing of fish and plants in the Black Sea is cited. (TTT)

**17988** (ORO–2412-18) COMPOSITIONAL CHANGES OF ECOSYSTEM SEGMENTS DURING CHRONIC GAMMA IRRADIATION. Garrett, Arthur R. Jr. (Emory Univ., Atlanta, Ga.). 1968. Contract AT(40-1)-2412. 144p. Dep. CFSTI. Thesis.

A series of observations were made on segments of granite outcrop ecosystems during chronic gamma irradiation. Samples were taken on ten dates during a 14-month period. Dose rates covered the interval from 161 to 0.1 R/hr for total doses ranging between 1356 and 0.8 kR. Samples of vegetation, litter arthropods and soil nematodes were quantitatively studied. The number of nematodes generally declined with increasing irradiation. The values of the index of similarity and 10 diversity indexes for the vegetation and litter arthropods are presented as annual progressions or in terms of their regression on radiation exposure and time. Similarity considerations seem more informative regarding vegetation changes. Diversity indexes seem more appropriate to describing changes in litter arthropod samples. The indexes are useful as concise descriptive statements of change in taxonomic composition of ecosystems. (auth)

## Genetics and Cytogenetics

*Refer also to abstracts 18136 and 18143.*

**17989** (CONF-681006–, pp 143-6) RADIATION PHYSIOLOGY AND MICROBIOLOGY OF FRUIT DETERIORATION. Sommer, Noel F. (California Univ., Davis).

The effects of γ-irradiated sucrose solutions and juice and puree of strawberries on anaphase chromosomes of Vicia faba roots were studied. Seedling roots were treated 4 hr in 200-krad irradiated and control solutions of 2% sucrose adjusted to pHs ranging from 2.5 to 5.0. As the pH decreased, the percentage of abnormal anaphases after treatment with both types of solutions increased. No significant differences were found between percentages of abnormal anaphases in roots treated with irradiated and control solutions. In roots treated 4 hr with juice or puree from irradiated (200 or 400 krad) and control strawberries, no significant differences were found. (C.O.)

**17990** STUDIES ON RADIATION-SENSITIVE MUTANTS OF E. COLI. III. PARTICIPATION OF THE REC SYSTEM IN INDUCTION OF MUTATION BY ULTRAVIOLET IRRADIATION. Miura, Akiko; Tomizawa, Jun-ichi (National Inst. of Health of Japan, Shinagawaku). Mol. Gen. Genet., 103: No. 1, 1-10(1^68).

The bacterial recA gene participates in the induction by uv irradiation of the clear mutation of phage λ and the $Lac^-$ mutation of bacteria. The necessary function is induced by irradiation of $Rec^+$ bacteria and acts upon DNA irradiated with uv light. (auth)

**17991** ANALYSIS OF A CASE OF MUTAGEN SPECIFICITY IN NEUROSPORA CRASSA. I. DOSE-RESPONSE CURVES. Auerbach, C.; Ramsay, D. (Inst. of Animal Genetics, Edinburgh). Mol. Gen. Genet., 103: No. 1, 72-104(1968).

The data are discussed from two points of view: mutagen specificity, and the meaning of dose-response curves in mutation research. The main results are as follows. If mutagen specificity is defined as an overall excess of one type of reversion over the other, then three mutagens (UV, NEU, NMU) are specific for the inositol-allele, and four mutagens (X, HF, NA, DEB) are specific for the adenine-allele. For all mutagens, the degree of specificity is dose-dependent, for some of them (HF, NA, DEB) strongly so. X and HF (which probably resembles X in its mode of action) are the only mutagens that show marked specificity already at the lowest doses. For all other mutagens, specificity is greatly reduced or altogether abolished at the lowest doses. Even DEB, which at high doses may produce several hundred times as many adenine- as inositol-reversions, produces only a few times as many at very low doses or when given to a growing culture instead of to a suspension of conidia. The kinetics of mutation induction varied between mutagens; they rarely were the same for the two reversion types and could be modified by experimental conditions. The curves relating reversion frequency to dose varied from less than linear to more than quadratic. In most experiments, the dose exponent was higher for the more frequent reversion type than for the less frequent one. Reasons are given for considering the dose-response curves as composite ones in which the one-hit kinetics of the primary reaction between mutagen and DNA is overlaid by the kinetics of treatment effects on cellular conditions relevant to the mutation process. The strong exponential component ($e^{c \cdot dose}$) found in some of the dose-response curves suggests, but does not prove, that exponential inactivation of a repair enzyme may be one of these components. (auth)

**17992** EXPERIMENTAL STUDIES ON THE MECHANISM INVOLVED IN THE MAINTENANCE OF GENETIC VARIABILITY IN DROSOPHILA POPULATIONS. Mukai, Terumi (North Carolina State Univ., Raleigh). Idengaku Zasshi, 43: 399-413(Dec. 1968).

The mechanism involved in the maintenance of genetic variability with respect to fitness in random mating populations was studied by accumulating spontaneous mutant viability polygens in the second chromosome of Drosophila melanogaster. First, the spontaneous mutation rate of viability polygenes was estimated. Simultaneously, the recessive lethal mutation rate was estimated as 0.006/second chromosome/generation. Using the same experimental material, radioinduced mutation rates were determined after treatment with 500 R of x rays. Conclusions are outlined and discussed. In general, it was concluded that only 10 to 14 heterozygous loci per second chromosome, on the average, can explain the actual situation in random mating populations. (C.O.)

**17993** TECHNIQUES FOR STUDYING THE EFFECTS OF RADIATION ON MEIOSIS AND RELATED PROCESSES IN MOSQUITOES WITH PARTICULAR REFERENCE TO AEDES AEGYPTI. Rai, K. S. (Univ. of Notre Dame, Ind.). pp 185-200 of Effects of Radiation on Meiotic Systems. Vienna, International Atomic Energy Agency, 1968. (COO-38-538).

Methods used in studying cytogenetic and genetic effects of radiation and certain radiomimetic chemicals (chemosterilants) on the yellow fever mosquito, Aedes aegypti, are described. The effects of γ and x radiation on the meiotic and mitotic cycles, oviposition and egg hatchability, rate of growth and development, viability to adulthood, longevity, and reproductive capacity were studied by exposing various immature and mature stages to radiation doses ranging from 500 to 6400 R. Sterility doses and relative radiosensitivity of various stages were established. General cytological techniques for studying male meiosis, spermatogenesis, oogenesis, ovarian transplants, and mitosis are described in detail, as were cytogenetic techniques for isolating specific chromosomal aberrations. A technique for detection of radiation- or chemosterilant-induced sex-linked recessive lethal mutations on chromosome I of A. aegypti is also described. (C.O.)

**17994** RADIATION DAMAGE TO CHROMOSOMES. Wolff, Sheldon (Univ. of California, San Francisco). IEEE (Inst. Elec. Electron. Eng.), Trans. Nucl. Sci., NS-15: No. 6, 30-3 (Dec. 1968).

From Annual Conference on Nuclear and Space Radiation Effects, Missoula, Mont. See CONF-680706.

A brief discussion of the effects of radiation on chromosomes is presented. Effects on genetic apparatus, chromosome aberrations including one-hit and two-hit, modifying factors, relative biological effects, and oxygen effects are summarized. (W.H.K.)

**17995** EVIDENCE FOR MULTIPLICITY REACTIVATION OF ULTRAVIOLET LIGHT IRRADIATED RIBONUCLEIC ACID ISOLATED FROM TOBACCO MOSAIC VIRUS. Takahashi, Tsuyoshi; Hayashi, Takaharu (Inst. for Plant Virus Research, Tokyo). Jap. J. Microbiol., 12: 187-93(June 1968).

Multiplicity reactivation (MR) seemed to take place in leaves of Nicotiana glutinosa inoculated with ultraviolet-(UV) irradiated RNA from tobacco mosaic virus (TMV-RNA). A similar phenomenon was not observed with UV-irradiated TMV particles. Considering MR as resulting from genetic recombination between viral genomes, a recombination mechanism, which was difficult to prove with plant viruses, was proposed as being operative during multiplication of TMV. From the pattern of MR of TMV-RNA, the location of the gene for the RNA replicase within a TMV-RNA strand was discussed. (NSA of Japan)

**17996** ACTION OF OXIDIZED OLEIC ACID ON THE CHROMOSOME APPARATUS OF BONE MARROW CELLS. Graevskaya, E. E. (Moscow State Univ.). Radiobiologiya, 8: 920-1(1968). (In Russian).

The work presents the results of an investigation of the effects of oxidized oleic acid on the chromosomes of mouse bone marrow cells. A conclusion is drawn on the possible role of oxidized products of unsaturated fatty acids in the remote effect of x radiation on rats. (JPRS)

**17997** LIFETIME OF CLEAVAGES AND CONSERVATION OF ACUTE RADIATION DAMAGE TO CHROMOSOMES IN CULTURES OF CHINESE HAMSTER FIBROBLASTS, STABILIZED BY A REDUCED TEMPERATURE OF INCUBATION. Lubennikova, E. I.; Shapiro, I. M. (Inst. of Animal Morphology, Moscow). Radiobiologiya, 8: 816-21(1968). (In Russian).

During the incubation of cultures at 15°C, chromosome cleavages in cells x irradiated at the S and $G_2$ stages remain open. Judging by the yield of chromosome rearrangements, the effect of acute irradiation is preserved in cells irradiated at the S- and $G_2$ stages in the period of incubation of the cultures at 15°. At 15° the number of exchanges in cells irradiated in the $G_2$ period is approximately twice as high as in the S-period. (JPRS)

## Health Physics and Safety

*Refer also to abstracts 17362, 17527, 17805, 17822, 17826, 17900, 17926, 17971–17973, 17976, 17977, 17981, 17985, 18121, 18143, 18177, 18259, 19102, and 19522.*

**17998** (AEC-tr-7030) USSR REPORTS ON NATURAL AND FALLOUT RADIOACTIVITY. Translation of Russian articles. 173p. Dep. CFSTI.

Separate abstracts were prepared for 16 papers of this report. Distribution of radioisotopes in the soil and other aspects of environmental contamination are considered. (H.L.W.)

*For abstracts of individual papers see: 17345, 17550–17554, 17571, 17626, 17893, 17961, and 17999–18004.*

**17999** (AEC-tr-7030, pp 1-13) PECULIARITIES OF THE MIGRATION OF TOTAL $^{137}Cs$ FROM SANDY PODZOLIC SOILS THROUGH THE FOOD CHAIN INTO THE HUMAN BODY. Moiseev, A. A.; Mukhin, I. E.; Pogodin, R. I.; Antropova, Z. G.; Filimonov, G. V. Translation of report A-AC-82/G/L-1187.

Soil, hay, cereals, milk, meat, and total diet for the inhabitants of two populated sites were sampled in November, 1966, and the $^{137}Cs$ body burden of people of various age groups was measured with a portable single-channel gamma spectrometer. Tables are presented to show results. On transferring from turf-podzolic sandy soils along the food chain, $^{137}Cs$ reaches higher levels in

vegetation, in agricultural products (meat and milk), and in the body of the inhabitants of that district. Increased $^{137}Cs$ content in individual links of the soil-vegetation-cow-man chain is caused only by specific conditions of the soil in the given area, that fixes the fallout $^{137}Cs$ only weakly. The average body burden of $^{137}Cs$ of adults living in these areas is 55 $\mu$Ci. The internal $^{137}Cs$ gonad doses to the adult population of the area fluctuated from 3 to 17 mrad/yr. (H.L.W.)

**18000** (AEC-tr-7030, pp 26-39) $^{90}Sr$ IN BONE IN THE SOVIET UNION (1957-1967). Marei, A. I.; Barisov, B. K.; Barkhudarov, R. M. Translation of report A-AC-82/G/L-1244.

Levels of $^{90}Sr$ produced by nuclear weapons tests in various populations of the Soviet Union during 1957 to 1967 were evaluated. Pathological specimens were obtained from 99 cities in various geographical districts chosen for climatic and other factors that might influence the uptake of $^{90}Sr$. Bone and teeth specimens were dried and ashed and measurements were made with low background counters. Results are shown by means of tables and graphs. Changes in $^{90}Sr$ concentration were characterized by a considerable rise during 1963 to 1966; in adults a tendency towards lower values was noted in 1967. The highest mean annual bone dose from $^{90}Sr$ was observed in 1964 for children born in 1962. (H.L.W.)

**18001** (AEC-tr-7030, pp 40-8) DIETARY INTAKE OF $^{90}Sr$ AND $^{137}Cs$ BY THE POPULATION OF THE USSR IN 1966-1967 AS A RESULT OF STRATOSPHERIC FALLOUT. Petukhova, E. V.; Knizhnikov, V. A. Translation of report A-AC-82/G/L-1245.

Quantities of radioisotopes consumed by the population were determined by radiochemical and spectrometric methods. The tabulated results show that there was a decline in the $^{137}Cs$ and $^{90}Sr$ levels in basic food products. The rate of decline was different for milk, bread, cereals, meat, fish, vegetables, fruits, and water. During the first half of 1967 some population groups received a third to a half less of these radioisotopes than during the same period of 1966. (H.L.W.)

**18002** (AEC-tr-7030, pp 131-3) SOME QUANTITATIVE FEATURES OF ENVIRONMENTAL CONTAMINATION BY $^{90}Sr$ DURING A PERIOD OF STRATOSPHERIC DEPOSITION. Stepanov, Yu. S.; Barkhudarov, R. M. Translation of report A-AC-82/G/L-1252.

A study was made of $^{90}Sr$ uptake from soil and air by potatoes, grain, milk, and other dietary factors of the adult urban population in the entire Soviet Union following nuclear weapons tests. Mathematical models are given to represent $^{90}Sr$ concentrations in the environment. The relation between the content of $^{90}Sr$ in bones of children up to one yr of age and that in the mother's diet and cow's milk was studied. It was found that the mother's diet exerts an influence both during the child's prenatal development and during the first ten months of life. After weaning contamination of cow's milk determines changes in the $^{90}Sr$ concentration in bones of children. A table is presented to show confidence limits of correlation coefficients for milk, potatoes, wheat, and bones of children. (H.L.W.)

**18003** (AEC-tr-7030, pp 149-51) $^{137}Cs$ CONCENTRATION IN HUMAN HAIR AS AN INDICATOR OF THE AMOUNT OF THIS ISOTOPE IN THE BODY. Ramzaev, P. V.; Popov, D. K.; Ibatullin, M. S. Translation of report A-AC-82/G/L-1257.

Hair collected in Leningrad barber shops was analyzed for $^{137}Cs$ and potassium, and measurements were made of the $^{137}Cs$ content of the hair and body of reindeer herders. The tabulated results show a close correlation between amounts of $^{137}Cs$ in the hair and body. Results suggested that the concentration of the isotope along the length of the hairs was the same only if the amount of $^{137}Cs$ remained constant in the body during the entire period of hair growth. It was concluded that analysis of hair for $^{137}Cs$ can be used only for a radiation health evaluation of the mean dose created by $^{137}Cs$ in the body of the inhabitants of a particular region. (H.L.W.)

**18004** (AEC-tr-7030, pp 163-70) $^{210}Po$ IN THE HUMAN BODY AND IN THE ENVIRONMENT. Ermolaeva-Makovskaya, A. P.; Pertsov, L. A.; Popov, D. K. Translation of report A-AC-82/G/L-1260.

Determinations were made of the $^{210}Po$ content of the air, water, and food products in Leningrad. Food products analyzed were fish, meat, eggs, milk, wheat, barley, rye, tea, coffee, potatoes, and green vegetables. From data on the content of $^{210}Po$ in urine and feces it was estimated that the people of Leningrad ingest about 4 pCi per day. Determinations were made of the $^{210}Po$ and sulfur content of the tissues of smokers and non-smokers. Analyses of bones of smokers showed that the $^{210}Po$ content was two to three times greater than that of non-smokers. Ratios of the $^{210}Po$ content of the kidneys, muscles, and spleen to that of the liver were determined. Results are tabulated. (H.L.W.)

**18005** (CONF-670503-, pp 9-22) RADIOECOLOGY AND THE FEASIBILITY OF NUCLEAR CANAL EXCAVATION. Martin William E. (Battelle Memorial Inst., Columbus, Ohio).

As a prime contractor to the Atomic Energy Commission, Nevada Operations Office, the Battelle Memorial Institute, Columbus Laboratories, is responsible for the technical management of bioenvironmental and other studies to help judge the radiological-safety feasibility of nuclear-excavation plans for the construction of a sea-level canal across the isthmian region of Central America. As part of the program to predict external and internal radiation doses to human populations living in the vicinity of the proposed canal routes, extensive field studies of human, agricultural, forest, freshwater, and marine ecology have been undertaken by different subcontractor groups in eastern Panama and northwestern Colombia. The results of these studies, which will not be completed until June, 1968, will be combined with predictions of radionuclide production and initial fallout distribution to develop methods of estimating radionuclide transfer through tropical food chains and other environmental pathways leading to man. Estimates will be made of the kinds and quantities of radionuclides to be expected, during and after nuclear excavation, in the external environments and diets of native populations in different parts of the two study areas, and calculations of potential radiation doses to man will be based on these estimates. Owing to the nature of the problem and to the virtual absence of previous ecological studies in the area of concern, it has been necessary to make broad ecological studies of a fundamental nature. This paper reviews the progress of these studies to date and demonstrates that the assessment of potential radiological hazards in relation to nuclear-excavation projects is dependent upon the accumulation of ecological and biogeochemical data and the application of radioecological principles. (auth)

**18006** (CONF-670503-, pp 300-6) SEDIMENT RADIOACTIVITY IN THE COLUMBIA RIVER ESTUARY. Jennings, C. David; Osterberg, Charles (Oregon State Univ., Corvallis. Dept. of Oceanography).

Surface sediments of the Columbia River estuary contain more $^{51}Cr$ and $^{65}Zn$ than the river water flowing over them. Highest concentrations of radioactivity are found in fine sediments whose distribution is irregular and subject to variation with changing river flow. Columbia River radionuclides were measured in sediments at a distance of 10 km from the mouth of one of its small tributaries, sometimes with higher radionuclide concentrations than the Columbia River sediments. Sediment radioactivity was measured with an in situ $\gamma$-ray detector attached to a multichannel analyzer, making it possible to analyze many samples rapidly with a minimum disturbance to surface layers. (auth)

**18007** (CONF-670503-, pp 319-28) MEASUREMENTS OF BACKGROUND RADIATION IN AQUATIC HABITATS IN ALASKA. Likens, G. E. (Dartmouth Coll., Hanover, N. H. Dept. of Biological Sciences); Johnson, P. L. (Army Cold Regions Research and Engineering Lab., Hanover, N. H.).

Measurements of ionizing radiation, made during 1965 in nine lakes, three rivers, one hot springs area and adjacent terrestrial substrates in Alaska, indicated that the background radiation in these habitats varied greatly. The lakes were characterized by a small amount of ionizing radiation at mid-depths and increasing quantities near the air and sediment boundaries. Moreover, the radioactivity of the sediments near shore was up to 3.2 times as high as the sediment values near the center. This pattern of background radiation has been relatively consistent in natural lakes of diverse geographic areas; hence, a model for background radiation in freshwater lakes is proposed. Variations in this model were a function of local differences in geologic substrates and input of allochthonous materials. The radioactivity from sediments in ponds of the Arctic tundra was caused by naturally occurring radionuclides. (auth)

**18008** (CONF-670503-, pp 337-45) AN ESTIMATE OF THE RESPONSE RATE OF ALBACORE TO CESIUM. Folsom, T. R.; Young, D. R.; Sreekumaran, C. (Scripps Institution of Oceanography, La Jolla, Calif.).

A theoretical evaluation of the response of a large oceanic fish to variations in cesium in its natural environment is given. Concentrations of two cesium nuclides that were measured in surface waters of the N. Pacific as well as in individuals of albacore were used. Reasonable past environments of natural cesium (non-radioactive $^{133}Cs$) and fallout cesium (radioactive $^{137}Cs$) were assumed for certain individual albacore caught near California in 1965. Systematic collections of tunas were made in 1965 in view of their ability to accumulate high concentrations of cesium. A general form of mathematic framework was adopted for connecting dynamic behavior and ultimate equilibrium in fish that would simplify testing of migration rates and environmental factors. Albacore may respond to changes in cesium relatively rapidly. (H.L.W.)

**18009** (CONF-670503–, pp 363-71) CONCENTRATION OF $^{65}$Zn BY OYSTERS MAINTAINED IN THE DISCHARGE CANAL OF A NUCLEAR POWER PLANT. Salo, Ernest O. (Washington Univ., Seattle. Fisheries Research Inst.); Leet, William L. (Inter-American Tropical Tuna Commission, La Jolla, Calif.).

The accumulation of zinc-65 was measured in oysters (Crassostrea gigas) which were maintained in the discharge canal of a nuclear-powered electric power plant. Oysters of the 1962 and 1964 brood were reared on trays suspended from a raft in the discharge canal of the Humboldt Bay Power Plant of the Pacific Gas and Electric Company. Radioactive wastes are periodically discharged from the plant to Humboldt Bay via this canal. The monthly average concentrations of $^{65}$Zn in the waters of the discharge canal during the study ranged from $0.104 \times 10^{-2}$ pCi/ml to $1.963 \times 10^{-2}$ pCi/ml. Samples of oysters were removed as new groups were added. Three groups were maintained and sampled periodically for over 400 days. The concentration of $^{65}$Zn in the wet meats of the oysters varied from 0.99 pCi/g to 174.0 pCi/g. Changes in the concentrations of $^{65}$Zn in the oysters generally followed changes of $^{65}$Zn in the discharge waters. Concentration factors for the 1962 brood ranged from $5.6 \times 10^3$ to $1.2 \times 10^4$ and from $8.6 \times 10^3$ to $1.1 \times 10^4$ for the 1964 brood. Assuming a constant pumping and filtering rate for the oyster, an efficiency of absorption factor of less than 0.4% was determined for the 1964 brood. It was found that the maximum concentration that a human would derive from a protein diet of oysters raised in the canal would be well within the maximum permissible body burden. (auth)

**18010** (CONF-670503–, pp 372-9) RADIOZINC DECLINE IN STARRY FLOUNDERS AFTER TEMPORARY SHUTDOWN OF HANFORD REACTORS. Renfro, William C.; Osterberg, Charles (Oregon State Univ., Corvallis. Dept. of Oceanography).

Concentrations of $^{65}$Zn and total Zn were measured in starry flounders collected periodically over a one-year period from Alder Slough, a small arm of the Columbia River Estuary. The nuclear reactors at Hanford, Washington, that supply most of the $^{65}$Zn in the river were shut down for 45 days during this period. As a result, the input of radioactivity to the study area was greatly reduced and specific activity ($\mu$Ci $^{65}$Zn/g total Zn) in the flounders declined. The time required to reduce the $^{65}$Zn specific activity by one-half under these conditions in which the flounders continued to obtain $^{65}$Zn from their food web and water is termed ecological half-life. The ecological half-life for $^{65}$Zn in juvenile starry flounders was 139 days under the conditions prevailing in this study. The effective half-lives of $^{65}$Zn in three flounders held in the laboratory were 56, 91, and 162 days, depending on the initial concentration of $^{65}$Zn in each test fish. (auth)

**18011** (CONF-670503–, pp 380-8) $^{65}$Zn IN ECHINODERMS AND SEDIMENTS IN THE MARINE ENVIRONMENT OFF OREGON. Carey, Andrew G. Jr. (Oregon State Univ., Corvallis. Dept. of Oceanography).

Artificial radionuclides, induced in water used as a coolant in the Hanford reactors, are discharged into the Pacific Ocean by the Columbia River. Gamma-ray spectrometric measurements show that levels of $^{65}$Zn decrease in both sediments and benthic animals with distance from the mouth of the river and with depth of water. Although $^{65}$Zn decreases rapidly in animals below 400 meters, it was detected to 2900 meter depths in animals but not in the sediments. Levels of $^{65}$Zn in benthic animals appear to be associated with depth, distance from the point source, position of the Columbia River plume in the surface waters, and ecology of the organisms. The bottom fauna is thought to be important in determining the distribution of induced radionuclides on the ocean bottom. (auth)

**18012** (CONF-670503–, pp 493-504) ACCUMULATION OF FALLOUT RADIOISOTOPES BY BIVALVE MOLLUSCS FROM THE LOWER TRENT AND NEUSE RIVERS. Wolfe, Douglas A.; Schelske, Claire L. (Bureau of Commercial Fisheries, Beaufort, N. C. Radiobiological Lab.).

Bivalve mollusks have proven useful indicators of the distribution of fallout radioisotopes in an aquatic environment. Three species of filter-feeding mollusks, Elliptio complanatus, Rangia cuneata, and Polymesoda caroliniana, were collected from stations in the Trent and Neuse Rivers in Eastern Carolina at 4 to 6 week intervals for more than a year. The soft tissues of each species were ashed and analyzed for gamma radioactivity with a multichannel spectrometer and 4 × 4-inch NaI crystal. The concentrations of gamma-emitting fallout radioisotopes were monitored in Rangia over a 30-mile stretch of river and a salinity range of <0.1 to >15‰. Ruthenium-106, $^{144}$Ce, $^{137}$Cs, $^{54}$Mn, and $^{65}$Zn were present in all samples. After the Chinese nuclear tests in May and December 1966, the amounts of $^{141}$Ce, $^{103}$Ru, $^{95}$Zr–$^{95}$Nb, and $^{140}$Ba–$^{140}$La rose suddenly in the samples. Ruthenium-106 and $^{103}$Ru were more concentrated in Rangia from downstream stations (salinity range 6 to 15‰), whereas $^{137}$Cs was more abundant in the same species from fresher water (salinity range 0 to 8‰). Zirconium-95niobium-95 from the Chinese test in May remained in Rangia from freshwater stations after it was no longer detectable in the same species collected downstream. (auth)

**18013** (CONF-670503–, pp 553-5) $^{137}$Cs, STABLE CESIUM, AND POTASSIUM IN LOWLAND RICE. Myttenaere, C.; Bourdeau, Ph. (European Atomic Energy Community, Ispra (Italy). Joint Nuclear Research Center).

Stable cesium, potassium, and $^{137}$Cs from fallout were measured in lowland rice grown in 1964 near Vercelli, Italy. No correlation was found between the Cs and K contents of various plant parts. Flooding enhanced the uptake of stable Cs in the shoots. It also increased the specific activity of $^{137}$Cs (pCi $^{137}$Cs/$\mu$g Cs) in the plant. (auth)

**18014** (CONF-670503–, pp 571-7) FALLOUT RADIOISOTOPES IN GEORGIA LICHENS. Plummer, Gayther L. (Georgia Univ., Athens. Dept. of Botany).

Concentration values for 9 radioisotopes were studied in three lichens that may be ecologically equivalent to similar taxons inhabiting parts of the Arctic tundras. $^{137}$Cs in Parmelia conspersa during 1965 attained a mean concentration of 434 pCi/g dry weight, or 32 nCi/m$^2$, which corresponds to about 42 percent of the $^{137}$Cs believed to have fallen on the outcrops since 1945. Cladonia species, compared to Parmelia, generally held 0.1 of the radionuclides relative to biomass, but retained higher concentrations of radionuclides in a given area because more biomass occurred. Treatments with as much as 500 nCi/m$^2$ of $^{134}$Cs showed no significant loss of radiocesium after lichens were leached with heavy rainfall. The results suggest that Cladonia, particularly with a capacity to concentrate an undetermined limit of $^{137}$Cs, may incorporate all the radiocesium that might be expected from fallout debris. (auth)

**18015** (CONF-670503–, pp 578-86) ACCOUNTABILITY OF NUCLEAR FALLOUT DEPOSITED IN A COLORADO HIGH MOUNTAIN BOG. Osburn, William S. Jr. (Division of Biology and Medicine (AEC), Washington, D. C. Environmental Sciences Branch).

As a requisite to determining mechanisms of nuclear fallout cycling within and between various landscape units it is extremely helpful to know how much fallout has come down per unit area and not been subjected to ground-level redistribution (regional fallout). While Alexander (1961) outlines criteria to select such representative fallout sites for a portion of the world's terrestrial landscape and Bergh et al. (1961) describe another technique to locate representative sites in some Arctic and sub-Arctic areas, neither technique is applicable to high mountain regions. A method to locate Sphagnum moss sampling sites which reliably represent regional fallout deposition is presented. The effectiveness of particular bog sites to intercept and retain fallout nuclides is obtained by comparing the annual increase of fallout nuclides measured in Sphagnum moss cores to the sum of fallout entering by four carefully measured and separate mechanisms: snowfall, dust storms, rainfall and dry processes. The summation of amounts of gross beta radioactivity contributed by these four processes was about 28,927 pCi/dec$^2$ and reasonably approximated the total increase measured in the Sphagnum moss samples (27,653 pCi/dec$^2$). This agreement was interpreted as evidence that these bog sites were reliable sampling sites to determine regional fallout and that all major incoming fallout pathways were adequately accounted. (auth)

**18016** (CONF-670503–, pp 597-601) TRANSPORT OF FALLOUT RADIONUCLIDES IN THE GRASS-TO-MILK FOOD CHAIN STUDIED WITH A GERMANIUM LITHIUM-DRIFTED DETECTOR. Potter, Gilbert D.; McIntyre, David R.; Pomeroy, Deborah (California Univ., Livermore. Lawrence Radiation Lab.).

Fallout, presumed to have originated from the Chinese nuclear test of December 28, 1966, was deposited in Northern California on January 1 and 2, 1967. The transfer of radionuclides in dry fallout from pasture grass to cow's milk was studied with a lithium-drifted germanium detector. The radionuclides on the grass and in the milk were identified and specific nuclides were quantitated from the resulting gamma spectra. The particular "family cow" observed was probably a worst-case example for dry fallout in that almost all of its nutritional requirements were derived from a small pasture. The observed value of the $^{131}$I in the milk of this cow, 934 pCi of $^{131}$I/kg, could have been higher had this been a rainout. The study demonstrates the value of the new solid-state lithium-drifted germanium detectors for those working in the field of radioecology. (auth)

**18017** (CONF-670503–, pp 623-6) COMPARISON OF FALLOUT $^{137}$Cs ACCUMULATION AND EXCRETION IN CERTAIN SOUTHEASTERN MAMMALS. Jenkins, James H.; Monroe, J. Robert; Golley, Frank B. (Georgia Univ., Athens).

The radionuclide body burden in selected predator and prey

species was determined by the use of a whole-body counter constructed for this purpose. Determinations were made on live and dead specimens of varying ages and sex to compare backgrounds in animals from the Georgia and South Carolina Coastal Plain and Georgia Piedmont. Only $^{137}Cs$ and $^{40}K$ are ordinarily identified in wild mammals although other radionuclides are often detected in the plant material in the stomach. The wildcat accumulates more $^{137}Cs$ than does the gray fox, red fox, cotton rat, or rabbit. Coastal Plain animals have from two to five times more $^{137}Cs$ than Piedmont animals. The biological half-life of $^{137}Cs$ in the fox is around 30 days, which compares closely with that of the dog and pig but is only about one-half that of man. The fox, especially, may be a useful indicator of radiation levels since its food habits are not unlike those of a foraging man. (auth)

**18018** (CONF-670945–, pp 225-31) AEC COMMENT. (Division of Isotopes Development (AEC), Washington, D. C. Division of Biology and Medicine (AEC), Washington, D. C.).

FOOD — radiation processing of, AEC comment on shipping studies of (C.O.)

**18019** (JAERI–5017) ACTIVITIES IN THE DIVISION OF HEALTH PHYSICS AND SAFETY, APRIL 1, 1967–MARCH 31, 1968. (Japan Atomic Energy Research Inst., Tokyo). June 1968. 177p. (In Japanese). Dep.

Fifteen sections are included; separate abstracts were prepared for each. (P.C.H.)

*For abstracts of individual sections see: 17346, 17516, 17517, 17748, 17749, 17805, and 18020–18027.*

**18020** (JAERI–5017, pp 5-24) MEASURES FOR SAFETY. (Japan Atomic Energy Research Inst., Tokyo). (In Japanese).

Safety controls during 1967 were carried out with emphasis on: Establishment of methods for determining the locations and quantities of radioisotopes and nuclear fuels from a safety standpoint; Establishment of emergency countermeasures against major accidents. Routine works (safety training and education, safety inspection, training of emergency corps, etc.) in the Section of Operational Safety were carried out as in the previous years. Safety actions were taken positively and produced good results. The record of accidents was as follows: The number of labor accidents was somewhat larger than in the previous year, but they were all minor ones. The average exposure dose and maximum exposure dose in 1967 were the same as in the previous years. A $^{3}H$ gas leakage occurred in the 5.5 MeV VDG in June, but no personal injuries resulted. The following additional items were carried out in the year: The Emergency Program for major accidents was enacted in March, after careful discussion in and out of the Division. The Safety Committee made a report that staff of the Utilities and Maintenance Sections should participate in the safety night-duty system, to strengthen the safety control after the duty hours. A hazard indicating-sign board was designed from the fire fighting standpoint for radioactive facilities. (auth)

**18021** (JAERI–5017, pp 25-59) REACTORS AND LABORATORIES MONITORING. (Japan Atomic Energy Research Inst., Tokyo). (In Japanese).

The radiation monitorings, excepting the routine works, in each controlled area are as follows. (1) Radiation monitorings, associated with works under high radiation field such as maintenance of primary heat exchangers of JRR-2, monitoring and inspection of irradiated fuels of JAPCO at the Hot Laboratory, were performed extensively; all works were carried out successfully for the planned exposure doses. (2) On the basis of hazard analysis and safety survey on the tritium gas target used at the 5.5 MeV Van de Graaff, new tritium-handling procedure and equipment were introduced. (3) An airborne activity monitoring system for the Isotope Production Plant No. 1 was completed. The measured release amount and concentration of airborne iodine were about one tenth of the expected values. (4) During the regular reactor maintenance, the radiation levels, inside the reactor vessel of JPDR, were measured and useful data were obtained for the JPDR-II project. (5) Fast Critical Assembly went critical on April 29, 1967, and radiation monitoring, inside and outside the reactor building, was performed during the characteristic tests at 100-watt operation. (6) The radiation monitoring system at the Fuel Reprocessing Test Plant was completed before its hot operation which started on May 27, 1968. (auth)

**18022** (JAERI–5017, pp 60-9) PERSONNEL MONITORING. (Japan Atomic Energy Research Inst., Tokyo). (In Japanese).

Personnel monitoring was carried out as in the preceding year. The number of workers wearing film badges this year increased to about 1.4 times that in the preceding year. The average annual external dose was 34 mrem, equal to the value in the previous year, and the maximum annual dose per person decreased to 750 mrem compared with 1,110 mrem last year. Bioassay and whole-body counting were carried out as in the preceding year. Services were extended to the Oarai Research Establishment, JAERI, this year. No internal contamination was found in routine urinalyses. However, minor contaminations were detected in 29 personnel by special examination of the excreta following incidental intakes. Inhalation of tritium occurred very frequently. The estimated doses of tritium were significant but all were under the permissible levels. The whole-body counting was performed once a year for 78 selected personnel of Tokai, Oarai, and Tokyo Laboratories of the JAERI. No personnel had any $\gamma$ nuclides other than $^{40}K$ and $^{137}Cs$. Counters were also used for detection of $^{131}I$ in the thyroid of the personnel who engaged in $^{131}I$ production; no $^{131}I$ was detected in them. When any contamination was suspected, it was checked immediately. In this way, skin and internal contaminations were found in 16 persons. The maximum dose in the year was 1.4 rem by the irradiation of skin with $^{58}Co$; other estimated doses were small. Wound contamination with $^{60}Co$ and $^{58}Co$, inhalation of $^{3}H$ gas, etc., are described in detail in the figures and tables. (auth)

**18023** (JAERI–5017, pp 70-6) ENVIRONMENTAL MONITORING. (Japan Atomic Energy Research Inst., Tokyo). (In Japanese).

Environmental monitoring during 1967 included the following: continuous radiation monitoring at fixed points around the site, moving survey of the radiations, monitoring of radioactive concentrations in the environment, meteorologic observations, and oceanographic survey. The moving survey was carried out with scintillation equipment on a survey car, and useful data were obtained. In the monitoring of environmental materials, emphasis was placed on nuclide analyses. Meteorologic and oceanographic observations were carried out both in Tokai and in Oarai. (auth)

**18024** (JAERI–5017, pp 89-93) SAFETY TECHNOLOGY DEVELOPMENT. (Japan Atomic Energy Research Inst., Tokyo). (In Japanese).

Studies were made on safety techniques in connection with the safety inspection of the radioactive facilities especially from a fire-protection standpoint. Investigations were made on the criteria for various radiological hazards to establish exact and rapid countermeasures of fire fighting in such facilities. A literature survey was conducted on the methods of fire protection in plutonium facilities, especially the ventilation system and fire extinguishing agents. Studies were made on hot caves and hot cells from a fire prevention standpoint. Some technical devices were made to prevent other kinds of hazards such as in a lathe operation of beryllium metal. (auth)

**18025** (JAERI–5017, pp 94-106) RADIATION CONTROL IN NUCLEAR FACILITIES. (Japan Atomic Energy Research Inst., Tokyo). (In Japanese).

In order to perform effectively the radiation monitoring in the controlled areas and to control properly the exposures, the following were carried out. (1) To improve the air monitoring techniques for the volatile radioactive materials such as iodine and chlorine, two types of charcoal-impregnated filter paper were newly manufactured and the collection performance was tested under the various sampling conditions using airborne radioiodine-131. (2) In-place tests concerning performance of Model 7 EE Charcoal Filter for removal of airborne iodine were conducted over the period of one year and the results obtained were satisfactory. Charcoal cartridges which are used for a full face mask and commercially available were examined for the removal efficiency of airborne radioiodine. (3) Polymer films used as the materials of protective clothing and gloves were tested for the permeability of tritiated heavy water and its vapor. (4) Amounts, properties and particle size distribution of airborne radioactive materials produced during the cutting and grinding of irradiated fuels of JAPCO at the Hot Laboratory were examined by autoradiography techniques etc. (5) Planning on radiation monitoring system of the $\alpha-\gamma$ cave scheduled to construct in Oarai area was done. (auth)

**18026** (JAERI–5017, pp 149-53) INTERNAL EXPOSURE. (Japan Atomic Energy Research Inst., Tokyo). (In Japanese).

The following studies were carried out in 1967: Day-to-day variation of dietary intake and urinary excretion of fallout $^{137}Cs$ and stable K in man, determination of Pu in blood by anion exchange method (preliminary report), and measurement of recovery by $^{85}Sr$ tracer in the chemical determination of fallout $^{90}Sr$ in urine, feces, and total diet. (auth)

**18027** (JAERI–5017, pp 154-62) ENVIRONMENTAL RADIATION AND CONTAMINATION. (Japan Atomic Energy Research Inst., Tokyo). (In Japanese).

Research and development activities in this field were carried out in many aspects. Results of the oceanography research con-

cerned with the national project of sea contamination were reported. Studies that are important to the evaluation of air and ground contamination from gaseous effluent released from atomic facilities were carried out. A measuring method for water contamination, using a scintillation counter was developed by research for water monitoring. (auth)

**18028** (JAERI-5017, pp 163-5) RADIOACTIVE WASTE TREATMENT AND DECONTAMINATION. (Japan Atomic Energy Research Inst., Tokyo). (In Japanese).

Research and development carried out in the field of radioactive decontamination in 1967 consisted of: studies on radioactive contamination and decontamination of solid surfaces; and studies on $^{239}Pu$ skin contamination and its decontamination. (auth)

**18029** (NP-17776) ENVIRONMENTAL RADIOACTIVITY IN NEW ZEALAND AND RESULTS OF EXTENDED MONITORING OF FALLOUT FROM FRENCH NUCLEAR TESTS IN THE PACIFIC. Quarterly Report, July-September 1968. (National Radiation Lab., Christchurch (New Zealand)). 28p. (NRL-F-31). Dep.

Results of routine monitoring of fallout during the third quarter of 1968 are tabulated. An increase in total beta activity in air and rain water owing to nuclear testing in the Pacific was noted. Graphs and tables are presented to show content of $^{90}Sr$ in rain, and $^{137}Cs$ and $^{90}Sr$ in milk. Results of extended monitoring of fallout from French nuclear tests in the Pacific are presented for $\gamma$ radiation, total beta activity in air and rain water, $^{89}Sr$ in rain, and $^{131}I$ in milk and cattle thyroid. (H.L.W.)

**18030** GENERAL PRINCIPLES OF MONITORING FOR RADIATION PROTECTION OF WORKERS: REPORT BY COMMITTEE 4 OF THE INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION. (Adopted by the Commission on May 24, 1968). ICRP Publication No. 12. Oxford, Pergamon Press, 1969. 30p. 15s.

The subject is dealt with under the following headings: Introduction; recommendations of the Commission; the functions of monitoring; monitoring of the workplace for external radiation; monitoring of the workplace for surface contamination; monitoring of the workplace for air contamination; individual monitoring for external radiation; monitoring for skin contamination; individual monitoring for internal contamination. Appendixes include: Criteria for selecting workers for individual monitoring for external and for internal contamination. (UK)

**18031** MEDICAL PROGRAM FOR NUCLEAR POWER STATIONS. Franco, S. Charles (Consolidated Edison Co. of New York, Inc., N. Y.). J. Occup. Med., 11: 16-25(Jan. 1969).

The operation of the Indian Point Nuclear Reactor of the Consolidated Edison Company since August 1962, gave firm evidence of the effectiveness of plant design and the reactor safety program. The adequacy of the present nuclear power reactor safeguards was proved by the experience of the Medical Department in regard to personnel, operation, and monitoring of the surrounding environment. The facilities of the Medical Department were standard, except for provisions of a decontamination area and special attention to possible contaminated cases with trauma. The duties of the industrial medical department in a nuclear power station were defined as follows: radiation health protection, decontamination procedure, plan for medical aspects of potential radiation accidents, and routine medical services; these constituted the major medical activities. To prevent radiation injury, the Health Physics Section was responsible for monitoring of radiation and personnel protection. The Medical Department responsibility was confined to preplacement examination to eliminate certain abnormally radiosensitive individuals, follow-up examination, and special examinations in case of exposure. The medical examination of personnel called for routine procedures. Special examinations by slit-lamp, bioassay, and whole-body counting were required mainly in special circumstances. (C.O.)

**18032** CONTROL OF RADIATION HAZARDS. ROLE OF THE HEALTH PHYSICIST. Hughes, Lewis (Univ. of California, Berkeley). J. Occup. Med., 11: 30-2(Jan. 1969).

The role of health physicists in surveillance of departmental activities, radiation monitoring, and provision of services to the public in radiation safety at the University of California is outlined. The radiation protection program is primarily based on controlling the hazard(s) at the source, or by engineering for safety aspects before allowing purchase or receipt of radioisotopes or radiation-producing equipment. (C.O.)

**18033** CONTROL OF RADIATION HAZARDS. ROLE OF THE ENVIRONMENTAL HEALTH SCIENTIST. Schmelzer, Lawrence L. (Univ. of California, Berkeley). J. Occup. Med., 11: 33-6(Jan. 1969).

The role of the environmental health scientist in investigation of environmental radiation hazards, evaluation of potential radiation damage to man and his environment, and development of concepts for prevention of radiation injury is discussed. The recognition and need for such personnel are also discussed. (C.O.)

**18034** INDICATION OF ADSORBED DOSE IN CRITICAL ORGANS BY ENERGY INDEPENDENT PERSONNEL DOSIMETERS. Piesch, E. (Karlsruhe Nuclear Research Center, Ger.). Health Phys., 15: 145-53(Aug. 1968).

The radiation hazard to a person may be determined by a personnel dosimeter worn on a representative part of the body. According to the ICRP recommendations, the absorbed dose in the critical organs has to be measured. There are different possibilities for estimating an organ dose by a personnel dosimeter. The dose reading can be related to the absorbed dose in the critical organ caused: by a homogeneous irradiation incidence, or by an irradiation incidence with maximum hazard to a person (frontal exposure or exposure from the back). In routine personnel dosimetry energy-independent dosimeters will be preferred. Experiments showed that a more accurate indication of organ dose will, however, be given by personnel dosimeters with certain energy dependence. Personnel dosimeters, especially spherical phosphate glass dosimeters, are described which simultaneously indicate the absorbed dose in the bone marrow, gut mucosa, testes, ovaries and lenses of the eye independent of the radiation energy above 50 keV. The possibilities of interpreting an organ dose and the measuring accuracy for personnel dosimeter readings are discussed. (auth) (UK)

**18035** INVESTIGATION OF $^{222}Rn$ CONCENTRATION IN THE ONCOLOGICAL DEPARTMENT OF THE REGIONAL HOSPITAL WITH POLYCLINICS IN OSTRAVA. Hillova, J.; Berankova, L. Prac. Lek., 20: 400-2(Oct. 1968). (In Czech).

The type of regular control of Rn 222 concentration in exposed places of the Oncological department of the Regional Hospital with Polyclinics in Ostrava is presented; further recommendations are discussed regarding improvement of hygienic conditions of such workplaces. A more sensitive method for estimation of leakage of radium applicators than those used up to date, i.e., adsorption on activated carbon, based on boiling off the radium-applicators in water and estimation of Rn 222 in bath, is recommended. It is proposed that safe deposits for applicators with exhaustor, which should be put in operation 30 minutes before opening of the safes, be provided. (auth)

**18036** CONTROL OF RADIATION HAZARDS. ROLE OF PHYSICIAN. Tabershaw, Irving R. (Univ. of California, Berkeley). J. Occup. Med., 11: 26-9(Jan. 1969).

An evolutionary sketch is presented of the medical administrative policy and practice in control of radiation hazards at University of California, Berkeley. The role of the physician in this program is delineated. The rationale and the future of preventive medical programs for radiation control are discussed in relation to the Berkeley policy and practice. (C.O.)

**18037** RADIATION PROTECTION PROGRAM AND RECORDS CONTROL SYSTEM OF PACIFIC TELEPHONE. Greene, Clyde C. Jr. (Pacific Telephone and Telegraph Co., San Francisco). J. Occup. Med., 11: 37-42(Jan. 1969).

An evolutionary sketch is presented of the program at Pacific Telephone and Telegraph Company used for radiation protection of personnel and maintenance of the cumulative radiation exposure records. Forms used to maintain the cumulative exposure records are illustrated. (C.O.)

**18038** DETERMINATION OF ABSORBED DOSE OF HeLa S3 CELLS CULTURED ON PLASTIC AND GLASS DISHES FOLLOWING EXPOSURE TO X-RAY. Masuda, Kouji (Kyushu Univ., Japan). Nippon Igaku Hoshasen Gakkai Zasshi, 28: 98-101(Apr. 1968).

The factors in converting roentgens into rads for mammalian cells HeLa S3 grown on the non-tissue equivalent materials and exposed to x-rays were determined experimentally. The results of these experiments indicate that the absorbed dose of radiosensitive structure related to cell replication is 1.22 when irradiated on glass dish (average effective atomic number: 11.6) and 0.86 when irradiated on polystyrene dish ($Z_{eff}$: 5.7) by HVL 0.35 mm Cu x-rays. (auth) (NSA of Japan)

**18039** TRANSFER OF TRITIUM OXIDE FROM MOTHER TO FETUS AND PECULIARITIES OF DEVELOPMENT OF THE OFFSPRING OF RATS IN THE PERIODS OF PRENATAL AND POSTNATAL LIFE. Lyaginskaya, A. M.; Istomina, A. G. (Inst. of Biophysics, Moscow). Radiobiologiya, 8: 859-62(1968). (In Russian).

Tritium oxide in a dose of 0.3 $\mu$Ci/g, administered to female rats on the first day of pregnancy, creates a summary tissue dose in the body of the female equal to 305 rad during the period of pregnancy. This dose is not absolutely sterilizing, although in some of the fe-

male rats pregnancy was terminated as a result of death of all the embryos. The summary tissue dose of 412 rad, received by the fetus, proved to be 36% higher than that received by the mother. The tritium oxide content in the water extracted from the fetus, placenta, and uterus proved to be the same as in the water of the other organs, or $1.6 \cdot 10^{-6}$ Ci/ml. The tritium concentration in the dry residue of the tissues of the fetus was two to three times lower than in the dry residue of the soft tissues of the female.(JPRS)

## Medicine

*Refer also to abstracts 17670, 17753, 17754, 17827, 17828, 17833, 17915, 17954, 18122, and 18132.*

**18040** (CONF-670503–, pp 474-82) PHOSPHORUS TURNOVER BY CORAL REEF ANIMALS. Pomeroy, L. R. (Georgia Univ., Athens. Dept. of Zoology); Kuenzler, E. J. (North Carolina Univ., Chapel Hill. Dept. of Environmental Sciences and Engineering).

Phosphorus content and elimination rates were measured for dominant reef animals at Eniwetok Atoll, and flux of P through the organisms was expressed as turnover time ($T_t$). Herbivorous fishes appear to receive in their diet just enough P for growth and reproduction; this is reflected in a somewhat lower excretion rate and longer $T_t$ than would be predicted for organisms of their size, particularly the juveniles. Carnivorous animals and deposit feeders receive excess P in their diet, and their $T_t$ is not different than it would be in ecosystems with a more abundant P supply. Of 5 species of reef corals examined, 4 showed a very long $T_t$ and little flux of P to the environment. Tridacna crocea showed a typical $T_t$ for a mollusc of its size, but seemed to lose most P through that incorporated in living zooxanthallae that are subsequently lost. (auth)

**18041** (CONF-670958) PROCEEDINGS OF THE SYMPOSIUM IN NUCLEAR MEDICINE: ITS CURRENT STATUS IN MEDICAL PRACTICE, CLEVELAND, OHIO, SEPTEMBER 27–30, 1967. (Nuclear Medicine Inst., Cleveland, Ohio). 333p. Dep. CFSTI.

The use of short-lived radioisotopes for diagnostic scanning procedures is reviewed. Methods of isotope administration are included. Fifteen separate abstracts were prepared for individual papers. Two papers appeared previously in NSA. (C.O.)

*For abstracts of individual papers see: 18042–18056.*

**18042** (CONF-670958–, pp 1-30) USE OF SHORT-LIVED RADIONUCLIDES IN SCANNING. Stern, Howard S.; Scheffel, Ursula (Johns Hopkins Medical Institutions, Baltimore, Md.).

The use of short-lived radioisotopes for diagnostic scanning is reviewed. Molybdenum-99/technetium-99m and tin-113/indium-113 are the isotopes considered for diagnosis of blood, brain, kidney, liver, lung, spleen, and stomach disorders. (C.O.)

**18043** (CONF-670958–, pp 31-9) RADIORENOGRAPHY AND DYNAMIC SCANNING TECHNIQUES (MAJOR CLINICAL APPLICATION). Zum Winkel, Karl (Heidelberg Univ. (West Germany). Strahlenklinik).

Results of renography, scanning, and camera-scintigraphy in patients with inflammatory diseases, disturbed blood circulation, solitary and multiple defects and anomalies of the kidneys as well as impaired drainage of the upper urinary tract are presented and discussed. Indications for each method are given. Renography gives information about tubular function, blood circulation, and excretion of each kidney. Through scanning, the functioning tissue of the kidneys can be localized. Camera-scintigraphy gave the same results as scanning, but in addition showed the dynamic processes of the renal transport of iodine-131-labeled Hippuran. (auth)

**18044** (CONF-670958–, pp 40-70) CONVENTIONAL DIAGNOSTIC PROCEDURES AND PATHOPHYSIOLOGICAL CONSIDERATIONS. Kennady, John C. (California Univ., Los Angeles. Lab. of Nuclear Medicine and Radiation Biology).

A brief review of diagnostic procedures used in the evaluation of intracranial pathology is presented. Patients with subdural hematomas, post operative and metastatic brain tumors presented problems in brain scan interpretation and these are discussed. Iodine-131-labeled human serum albumin macroaggregates (10 to 50 $\mu$) brain hemisphere scans in patients with brain tumors showed areas of decreased radiodensity corresponding to areas of increased uptake in $^{99m}$Tc brain scans that indicated an impaired microcirculation within the tumor. Preliminary studies in cerebral hemodynamics by rapid sequential scintiphotography indicated another valuable parameter in the assessment of cerebral microcirculation. (C.O.)

**18045** (CONF-670958–, pp 71-5) BRAIN SCAN IN VARIOUS CLINICAL SETTINGS. Goodrich, Jack K. (Duke Univ., Durham, N. C. Medical Center).

Tailored, precision neuroradiography gave evidence of intracranial disease in a greater number of cases than did rectilinear brain scanning. When the radiographic procedures were conducted under less stringent conditions the validity of scan findings equalled or surpassed the radiographic results. The effectiveness of $^{99m}$Tc-pertechnetate in localizing brain lesions was only slightly less than that experienced with $^{203}$Hg- and $^{197}$Hg-chlormerodrin. A general review of brain scanning is also presented. (C.O.)

**18046** (CONF-670958, pp 76-87) TECHNIQUES AND RESULTS OF MULTINUCLIDE SCINTIGRAPHY ("MULTI-ISOTOPE SCANNING"). Oeff, Karl (Freie Universitaet, Berlin (West Germany)).

Methods were developed for simultaneous scanning of two or three isotopes with different $\gamma$-ray energies. The methods allowed for the dynamic correction of the superimposed scattered radiation of the higher energy isotope in the scan of the lower energy isotope. The optical methods made use of the principle of the subtraction technique in radiography: to get the net scan of the lower energy isotope the subtraction was done by using a photographical transparency or by an electronic subtraction apparatus. In the electronic methods the subtraction was continuously performed by a special circuit that contained a step-down counter and a differential counter to get the net rate of the second isotope over each point of the scanned area. (auth)

**18047** (CONF-670958–, pp 98-113) PHOTOSCANNING OF THE PLACENTA. Nelp, Wil B. (Washington Univ., Seattle. School of Medicine).

The use of photoscanning for visualization of the placenta is discussed and outlined. Particular emphasis is placed on diagnosis of placenta previa. (C.O.)

**18048** (CONF-670958–, pp 114-45) CARDIAC OUTPUT–CORONARY BLOOD FLOW AND PREDICTION OF CORONARY THROMBOSIS. Sevelius, Gunnar.

The method of determining cardiac output, coronary blood flow, pulmonary volume, heart volume, blood volume, and pericardial effusion from a radiocardiogram is described. Each measurement was compared with reference methods. Normal values and their distribution are presented. A multiple regression formula for predicting normal values is described. Cardiac output was estimated from blood volume, pulse, and age. Evaluation of the results was achieved by comparing determined values with the estimated. Results indicated that heart failure could be improved by controlling the total blood volume. A high risk period for myocardial infarction was recognized within 5 months with the help of the radiocardiogram in 8 out of 10 patients. (auth)

**18049** (CONF-670958–, pp 152-63) RADIOISOTOPE PROCEDURES IN THE DIAGNOSIS AND MANAGEMENT OF THYROID DISEASE. Sodee, D. Bruce (Nuclear Medicine Inst., Cleveland, Ohio).

The radiopharmaceutical $^{99m}$Tc-labeled-pertechnetate was evaluated in the study of thyroid physiology. Thyroid accumulation of intravenous pertechnetate in patients under study for thyroid disease was also investigated. The various procedures available for the study of thyroid physiology, as well as the results with the $^{99m}$Tc are presented and discussed. (C.O.)

**18050** (CONF-670958–, pp 164-78) RADIOISOTOPE TREATMENT OF HYPERTHYROIDISM AND THYROID CANCER. Blahd, William H. (California Univ., Los Angeles. School of Medicine).

The therapeutic efficacy of $^{131}$I in the postoperative management of thyroid cancer was investigated. Principles of management used in the investigation included total thyroidectomy, thyrotropic hormone administration to augment $^{131}$I uptake in tumor metastases, large dose $^{131}$I administration, and thyroid replacement therapy at tolerance dose levels. Evidence to support the efficacy of $^{131}$I in the management of thyroid cancer was found. (C.O.)

**18051** (CONF-670958–, pp 179-207) LIVER SCANNING WITH SPECIAL REFERENCE TO JAUNDICED PATIENTS. Eyler, William R.; DuSault, Lucille A.; Poznanski, Andrew K.; Schuman, Bernard M. (Henry Ford Hospital, Detroit, Mich.).

The use of $^{131}$I-labeled Rose Bengal for examination of the liver of jaundiced patients is discussed. Diagnostic features in the interpretation of the scans in relation to anatomical variations, congenital biliary obstruction, hepatocellular disease, intrahepatic masses, partial biliary obstruction, and other conditions were considered on the basis of clinical cases. It was concluded that while many cases of jaundice presented classical patterns of history, laboratory tests, and physical findings, there was a sizable fraction of jaundiced patients in whom the cause was not readily apparent. Liver scans done with $^{131}$I-labeled Rose Bengal were either diagnostic or very helpful. (C.O.)

**18052** (CONF-670958–, pp 208-28) PHOTOSCANNING OF THE LIVER AND OTHER ORGANS OF THE RES USING $^{99m}$Tc SULFUR COLLOID. Nelp, Wil B. (Washington Univ., Seattle. School of Medicine).

Visualization of the liver and other organs of the reticuloendothelial system using colloidal material labeled with $^{99m}$Tc is discussed. Topics covered included: basic radiopharmacology of the Tc-labelled colloid, fundamental clinical and diagnostic considerations of photoscanning of the liver, and principles of Tc-labeled colloid scanning of the spleen and bone marrow organs. (C.O.)

**18053** (CONF-670958–, pp 229-45) FIVE YEARS EXPERIENCE WITH PANCREATIC SCANNING. Sodee, D. Bruce (Nuclear Medicine Inst., Cleveland, Ohio).

Pancreatic scanning using $^{75}$Se-labeled selenomethionine was investigated for five years. Various techniques were applied and animal investigations were used to determine the usefulness of the various pancreatic stimulating protocols. Results of animal investigations as well as those carried out with the newer techniques are presented. (C.O.)

**18054** (CONF-670958–, pp 246-80) LUNG SCANNING WITH THE SCINTILLATION CAMERA. Miale, August Jr.; Landis, Glen A.; Moser, Kenneth M. (Georgetown Univ., Washington, D. C.).

The stationary detector scintillation camera proved to be practical for routine lung scanning. The technical factors important in producing good quality images are reviewed. Iodine-131-labeled macrosaggregated albumin was used to delineate regional pulmonary blood flow. While pulmonary embolism was the most frequent diagnostic possibility, other disease entities produced detectable alterations in lung radioactivity distribution. A representative group of cases including a variety of lung disorders is presented to illustrate the typical diagnostic features encountered; they are clinically interpreted. (auth)

**18055** (CONF-670958–, pp 281-309) LUNG PERFUSION AND AERATED SPACE ASSESSMENT BY SCINTISCANNING. Taplin, George V.; Dore, Earl K.; Poe, Norman D.; Swanson, Leonard A.; Greenberg, A. (California Univ., Los Angeles. School of Medicine. Los Angeles County Harbor General Hospital, Torrance, Calif. Nuclear Medicine Div. Olive View Hospital, Calif. Dept. of Radiology. Memorial Hospital, Long Beach, Calif. Dept. of Nuclear Medicine).

The basic concepts, test agents, and techniques for performing lung perfusion and radioaerosol inhalation scans are described. The significance of the lung images obtained was illustrated using selected cases in which scan data were correlated with laboratory data, pulmonary function measurements, and radiographic findings pertinent to the particular clinical situation. The inhalation scan was found to be a useful counterpart to the perfusion scan, particularly in the assessment of regional lung function. Combined perfusion-inhalation scans were considered helpful in the diagnosis and management of chronic tuberculosis and other bronchopulmonary diseases and were especially useful in rapid differential diagnosis of acute pulmonary embolism. Iodine-131- and $^{99m}$Tc-labeled compounds were used. (C.O.)

**18056** (CONF-670958–, pp 310-33) LUNG SCANNING APPLICATION IN CARDIOLOGY. Friedman, William F.; Braunwald, Eugene (National Heart Inst., Bethesda, Md.).

Iodine-131-labeled macroaggregates of human serum albumin were used to study the distribution of pulmonary blood flow in 161 patients with heart disease. Major findings concerning patients with mitral valve disease, intracardiac left-to-right shunts, and with tetralogy of Fallot subsequent to subclavian-pulmonary or superior caval-pulmonary anastomoses are discussed. It was concluded that scanning was safer, produced less discomfort, and provided more quantitative data concerning the distribution of pulmonary blood flow than either pulmonary arteriography or differential bronchospirometry. (C.O.)

**18057** PALLIATIVE IRRADIATION. Brady, Luther W. J. Amer. Med. Ass., 207: 1134-5(Feb. 10, 1969).

Twenty patients with either locally advanced bladder carcinomas for which definitive radiotherapy was not possible because of the patient's general condition, or with extension beyond the pelvis from primary carcinoma in the bladder underwent palliative irradiation. The degree of palliation in terms of control of dysuria, hematuria, pain, etc. was excellent. The plan was to deliver tumor doses of 3,000 to 4,000 rads to the pelvis in 3 to 4 weeks using supervoltage methods and parallel-opposed fields or a four-portal plan if hematuria was the primary problem. For metastatic lesions to bone, tumor doses of 3,000 rads in 3 weeks were delivered in an effort to control bone pain or discomfort from soft-tissue mass. It was concluded that the palliative radiotherapy possibly did not significantly influence the ultimate course of the disease, but did offer the patient significant degrees of relief from symptoms. (C.O.)

**18058** SYMPOSIUM ON COMPUTERS AND SCANNING, NEW ORLEANS, LOUISIANA, DECEMBER 16-17, 1965. Hidalgo, John U. (ed.). New York, Society of Nuclear Medicine, 1967. 216p. $5.00. (CONF-651210).

Separate papers were prepared for each of the twenty articles presented. (C.O.)

*For abstracts of individual papers see: 17753, 17754, 17827–17830, 17915, 18059–18071.*

**18059** CLINICO-PATHOLOGIC CORRELATION OF THE LIVER SCAN IN HEPATIC ABSCESSES. McConnell, Charles F. (Tulane Medical School, New Orleans, La.). pp 172-80 of Symposium on Computers and Scanning. Hidalgo, John U. (ed.). New York, Society of Nuclear Medicine, 1967.

See CONF-651210.

Twelve patients with liver abscesses proven by surgery, aspiration or autopsy are reviewed. The anatomic findings at the time of surgery and/or autopsy are compared with the gold-198 scan. Certain changes seen on the scan can be positively confirmed such as: position, size, and rupture. The inflammatory changes of the liver generally seen with hepatic abscesses do not significantly alter the concentration of gold-198 in the Kupfer cells and therefore the procedure provides an adequate method for investigation of these lesions. (auth)

**18060** INVESTIGATIONS OF BRAIN HEMISPHERE SCANNING WITH RADIOALBUMIN MACROAGGREGATES. Kennady, John C.; Taplin, George V. (Univ. of California, Los Angeles). pp 198-216 of Symposium on Computers and Scanning. Hidalgo, John U. (ed.). New York, Society of Nuclear Medicine, 1967.

See CONF-651210.

This report reviews and evaluates the results of basic studies in primates designed to determine the feasibility and potential hazards of brain hemisphere scanning with radioalbumin macroaggregates (RAMA) in man. The minimum toxic dose of 10 to 60 $\mu$ size RAMA in the monkey is approximately 2 mg of carrier albumin, based on careful serial histological examination — the most sensitive indicator of cerebrocortical damage. Only one or two microinfarcts were produced in five of six animals, although more than 200,000 were predicted from the number of aggregates administered. These lesions were located in layers four and five of the cerebral cortex and represent blockade of the penetrating nutrient arterioles at the precapillary level. In view of the millions of aggregates injected, the few lesions found were most likely produced by the occasional larger aggregates in the test material. Clinical application of RAMA for brain hemisphere scanning in man must await further improvements in RAMA suspensions. Methods need to be devised for eliminating aggregates larger than 60 $\mu$ and for increasing the specific activity of the radioalbumin as much as possible. When RAMA preparations become available with these modifications clinical investigations may be initiated with reasonable assurance of safety to the patient. (auth)

**18061** RADIOISOTOPE ENCEPHALOGRAPHY: BENIGN LESIONS OF THE BRAIN. Gilson, Albert J. (Univ. of Florida, Miami). pp 181-90 of Symposium on Computers and Scanning. Hidalgo, John U. (ed.). New York, Society of Nuclear Medicine, 1967.

See CONF-651210.

The radioisotopic cerebral scan is a valuable adjunct to diagnosis and management of intracranial lesions of non-neoplastic origin. The scan does not, however, replace any of the accepted diagnostic radiographic techniques. The principal advantage of the scan lies in its ability to serve as an innocuous screening procedure on patients with equivocal neurological findings. By initially screening our patients with brain scans, we have been able to materially reduce the number of negative cerebral arteriograms. At this stage of development we strongly feel that once a lesion has been detected by scanning, more established diagnostic procedures, such as angiography or ventriculography, should be performed and indeed are of great importance. (auth)

**18062** LUNG PERFUSION AND BRONCHIAL PATENCY EVALUATION BY RADIOISOTOPE SCANNING. PART I. PULMONARY ARTERIAL PERFUSION BY LUNG SCANNING. Taplin, G. V.; Dore, E. K.; Poe, N. D.; Swanson, L. A.; Johnson, D. E.; Greenberg, A. (Univ. of California, Los Angeles). pp 108-22 of Symposium on Computers and Scanning. Hidalgo, John U. (ed.). New York, Society of Nuclear Medicine, 1967.

See CONF-651210.

This paper describes radioalbumin microaggregates (RAMA) and their application for estimating regional pulmonary arterial blood flow on the principle of temporary arteriolar blockade. Based on clinical experience in over 1000 patients, currently available RAMA suspensions are entirely safe for lung scanning in nearly all patients. They are non-toxic and non-antigenic in

man and no reactions to the test material were encountered, even in seriously ill patients. The lung perfusion scan has the unique capacity to indicate regional pulmonary ischemia, far more often than such evidence is recognizable in conventional chest x-ray films. It discloses regional pulmonary dysfunction because areas of ischemic lung cannot possibly carry on normal gas exchange and may therefore replace differential spirometry. Scans may be repeated safely at frequent intervals to follow the course of pulmonary embolism and other diseases which alter pulmonary arterial blood supply. The perfusion scan is an excellent screening test for selecting patients for pulmonary angiography and may be helpful to the surgeon in planning his surgical attack. The need and advantages of developing RAMA suspensions of higher specific activity and more uniform size are discussed. (auth)

**18063** HEPATIC SCANNING: CURRENT STATUS. Croll, Millard N. (Hahnemann Medical Coll. and Hospital, Philadelphia, Pa.). pp 160-71 of Symposium on Computers and Scanning. Hidalgo, John U. (ed.). New York, Society of Nuclear Medicine, 1967.

See CONF-651210.

Liver scanning is a valuable, established diagnostic tool. It will provide information that is not available by any other nonoperative means and it does this without morbidity or mortality for the patient. There are multiple radiopharmaceuticals available for scanning and there is a continual progression of instrumentation. The physician, employing this modality, should be well versed in the normal appearance and should carefully select all of the variable factors in such a manner, as to produce the highest degree of diagnostic accuracy. (auth)

**18064** CLINICAL APPLICATION OF LUNG SCANS. Haynie, Thomas P. (Univ. of Texas, Houston); Meneely, George R. pp 89-93 of Symposium on Computers and Scanning. Hidalgo, John U. (ed.). New York, Society of Nuclear Medicine, 1967.

See CONF-651210.

The radionuclidic studies available for the study of pulmonary function to date include: radiopulmonography, inhalation of radioactive gases, inhalation of aerosolized particles, injection of soluble gases and injection of radioactive particles. These studies can be used for obtaining information with regard to the ventilation and perfusion of the lung; these practices are finding uses in the diagnostic evaluation of pulmonary embolism and infarction, bronchogenic carcinoma and pulmonary emphysema and tuberculosis. Improvements in terms of short-lived isotopes and better instruments of greater sensitivity and speed, should make these procedures even more valuable in the future. (auth)

**18065** JOINT SCANNING WITH LABELED ALBUMIN. Maxfield, William S.; Weiss, Thomas E.; Murison, Paul J.; Tutton, Roger H.; Hidalgo, John U. pp 143-59 of Symposium on Computers and Scanning. Hidalgo, John U. (ed.). New York, Society of Nuclear Medicine, 1967.

See CONF-651210.

Joint scanning with tagged albumin is an additional objective test that can demonstrate abnormality in the synovial membrane of patients with active arthritis. The correlation with clinical manifestations has been excellent. The joint scans in some patients have provided information not detected by routine roentgenography of the joints. Further investigation of use of $^{99m}Tc$ albumin for joint scans is under way as is the technique of intra-articular administration of the tracer. (auth)

**18066** TUMOR SCANNING WITH RADIOACTIVE $^{131}Cs$. Charkes, N. David; Sklaroff, David M.; Gershon-Cohen, J.; Canton, Robert E. (Albert Einstein Medical Center, Philadelphia, Pa.). pp 134-42 of Symposium on Computers and Scanning. Hidalgo, John U. (ed.). New York, Society of Nuclear Medicine, 1967.

See CONF-651210.

Fourteen patients with cancer were scanned 10 minutes to 48 hours after injection of radioactive $^{131}Cs$ and satisfactory scans of the tumors were obtained in seven. Positive scans were obtained in large, superficial tumors, in a pulmonary lymphoma and in a carcinoma of the upper third of the esophagus. The negative scans were all in abdominal tumors. Correlations were made with data obtained from external counting and by well scintillation counting of biopsy specimens. Two modes of uptake are suggested: early uptake due to vascularity and probably not proportional to stable cesium content; and a later uptake based upon greater alkali metal content of tumors than of normal tissue. (auth)

**18067** LUNG PERFUSION AND BRONCHIAL PATENCY EVALUATION BY RADIOISOTOPE SCANNING. PART II. BRONCHIAL PATENCY EVALUATION BY SCANNING AFTER RADIOAEROSOL INHALATION. Taplin, G. V.; Dore, E. K.; Poe, N. D.; Swanson, L. A.; Johnson, D. E.; Greenberg, A. (Univ. of California, Los Angeles). pp 123-33 of Symposium on Computers and Scanning. Hidalgo, John U. (ed.). New York, Society of Nuclear Medicine, 1967.

See CONF-651210.

The further development of a safe technique for visualizing the lower respiratory tract by chest scanning following inhalation of suitable radioaerosols is described. Two types of aerosol generators and inhalation equipment were used. Filtration of the exhaled air and channeling it into a ventilated hood, or to the outside atmosphere, prevents contamination of the examining room and personnel. Normally, inhaled radioprotective particles, smaller than 1 to 2 $\mu$, are evenly distributed throughout the lungs and penetrate to the distal alveoli. Perfusion and inhalation lung scans have nearly identical patterns in normal subjects. The inhalation scan represents the distribution of airborne particles deposited throughout the lower respiratory tract, but the amount of radioactivity in any given portion of the lung, is not always proportional to airflow to that region. When inhalation is performed with a subject in the lateral position, greater amounts of aerosol are deposited in the superior lung where ventilation and perfusion are reduced. With partial bronchial obstruction, increased deposition of radioaerosol may occur at the obstruction site and the region beyond usually shows reduced levels of radioactivity. Complete bronchial obstruction is readily detectable in the inhalation scan as an area devoid of radioactivity. A normal lung image indicates patency of the lower respiratory passages. (auth)

**18068** PULMONARY PERFUSION AND ALVEOLAR SCINTISCANNING. Quinn III, James L. (Northwestern Univ., Chicago). pp 94-107 of Symposium on Computers and Scanning. Hidalgo, John U. (ed.). New York, Society of Nuclear Medicine, 1967.

See CONF-651210.

Two types of lung scanning are presently available to the physician evaluating diseases of the pulmonary system, viz, pulmonary perfusion and bronchio-alveolar. The pulmonary perfusion scan, using radioalbumin macroaggregate has been shown to be of considerable aid in the early diagnosis of pulmonary embolic disease. The pulmonary bronchio-alveolar scan, currently under development and investigation in several laboratories, has been shown to be superior to the perfusion scan in outlining areas of pulmonary emphysema. Lung scans must be evaluated in the light of the chest roentgenogram findings to avoid pitfalls in the interpretation of radionuclide distribution abnormalities. (auth)

**18069** RADIOISOTOPE PLACENTOGRAPHY: SECTOR COUNTING AND PHOTOSCANNING TECHNICS. Gilson, Albert J. (Univ. of Miami, Fla.). pp 68-74 of Symposium on Computers and Scanning. Hidalgo, John U. (ed.). New York, Society of Nuclear Medicine, 1967.

See CONF-651210.

Two techniques for accurate placental localization are discussed. The first, sector counting, is for gross localization. The second, use technetium-99m and standard radioisotope scanners. (B.G.D.)

**18070** CARDIAC SCANNING AND LOW ENERGY COLLIMATORS. Goodrich, J. K. (Mississippi Univ., Jackson); Hill, F. S. Jr.; Hill, R. W. pp 75-88 of Symposium on Computers and Scanning. Hidalgo, John U. (ed.). New York, Society of Nuclear Medicine, 1967.

See CONF-651210.

An investigation of low-energy collimators used in radioisotope scanning of the myocardium is discussed. The fabrication techniques for a low-energy 91-hole collimator are described. (B.G.D.)

**18071** BRAIN SCANNING. Bender, M. A. (Roswell Park Memorial Inst., Buffalo, N. Y.). pp 191-7 of Symposium on Computers and Scanning. Hidalgo, John U. (ed.). New York, Society of Nuclear Medicine, 1967.

See CONF-651210.

Useful clinical brain scanning using high contrast photo recording techniques was first accomplished in 1957. Developments in scanning equipment and localizing agents (radiopharmaceuticals) since then are reviewed and evaluated. (C.O.)

**18072** RELATION BETWEEN THE EFFECT OF BONE MARROW GRAFTING IN RADIUM THERAPY AND THE QUANTITY OF CELLS INTRODUCED. Butomo, N. V.; Golubeva, L. A. (Leningrad Military Medical Academy). Med. Radiol., 14: No. 2, 27-31(Feb. 1969). (In Russian).

In experiments on irradiated dogs and mice the relation between the effect of bone marrow grafting and the quantity of cells introduced was studied. When using compatible bone marrow (autologous) there was a direct relationship between the number of myelocytes and the rate of hematopoiesis restoration in recipients. In transplantation of allogenic myeloid cells their large

quantity (1.2 to 1.5 billion/kg body weight) results in the development of signs suggesting an acute form of secondary disease. On the basis of extrapolation of experimental data a conclusion is made that the optimal content of allogenic cells transplanted for the purpose of treating acute radiation sickness in humans averages 20 to 30 billion. (auth)

**18073** STUDIES ON TIME FACTOR IN RADIOTHERAPY FOR CERVICAL CANCER OF THE UTERUS. PART II. CLINICAL STUDY. Furuta, Takafumi (Shinshu Univ., Japan). Shinshu Igaku Zasshi, 16: No. 6, 78-95(Dec. 1967). (In Japanese).

To obtain the most suitable dose-time relationship for radiotherapy of cervical cancer, the following clinical studies were performed. The pelvic dose distribution following bilateral eccentric pendulum irradiation was measured with a water phantom. Results showed that the dose given to the uterine cervix was about 70 to 85% of the B-point. Further, the doses in several pelvic sites of patients were actually measured with fluoroglass rod dosimeter. Results revealed that the actually measured doses were almost in accord with the values calculated from the pelvic dose distribution obtained with the water-phantom. The clinical results of 22 cases that were irradiated with a single dose of 230 R six times a week (A-Group), and 12 cases that were irradiated with a single dose of 345 R four times a week (B-Group) were compared. It was found that the degree of shrinkage of primary lesion was greater in the B-Group; histological study by biopsy revealed that the disappearance of cancer cells was a little more in B-Group when the external dose reached 4000 or 5000 R. In parametrial findings from internal examination, there was no difference between groups. As to side effects, erythrocyte count and hemoglobin content decreased in A-Group somewhat intensely; thrombocyte count, serum protein, serum alkaline phosphatase value decreased in B-Group somewhat intensely; and leukopenia and skin, rectum, and urinary bladder hazards showed no difference between both groups. (TSS) (NSA of Japan)

**18074** METHOD OF ELABORATING SCHEMES OF TRANSVERSE BODY SECTION FOR TELERADIOTHERAPY. Kalinichenko, M. A. (Scientific-Research Inst. of Oncology, Leningrad). Med. Radiol., 14: No. 2, 12-16(Feb. 1969). (In Russian).

For the elaboration of schemes of transverse body section the external contour at the level of neoplasm localization was taken. Then one carries out two perpendicular recordings with contrast tags on the patient's body. The recordings obtained are placed in turn on a table-negatoscope with a special correcting ruler. The latter helps to reproduce diverging beams of x rays passing through the patient's body in the frontal and lateral projections. The limits of contours of organs and tumor with a frontal and lateral radiogram are transferred by means of the correcting ruler on the scheme of transverse section. The sizes and mutual localization of organs and neoplastic focus on the scheme are of a natural size. (auth)

**18075** THE INFLUENCE OF S-2-AMINOETHYLISOTHIURONIUM ON THE DEVELOPMENT OF SCLEROTIC CHANGES IN THE KIDNEYS OF IRRADIATED ANIMALS. Nurgaliev, K. (Central Scientific Research Inst. of Roentgen-Radiology, Leningrad). Med. Radiol., 14: No. 2, 31-5(Feb. 1969). (In Russian).

A comparative study of the morphological picture of mouse kidneys at remote periods after irradiation demonstrated that sclerotic changes were more marked and encountered more frequently than in animals receiving AET and controls. This testifies to the protective effect of AET on the kidneys. Upon counting of the number of renal bodies per unit of area of the cortical layer it was found that this index is significantly higher in the group where mice were irradiated without protection, than in protected and control animals. The results made it possible to arrive at the conclusion that there is a varying degree of inadequacy of renal bodies in irradiated and protected animals. This in turn conditions an irregular mobilization and hypertrophy of reserve renal bodies in these animals. (auth)

**18076** COMBINED CHEMICAL AND HYPOXIC PROTECTION AGAINST WHOLE-BODY X-IRRADIATION IN THE NESTLING RAT. Shewell, Jennifer (St. Mary's Medical School, London). Radiat. Res., 36: 508-20(Dec. 1968).

Litters of 8- to 10-day-old nestling rats were protected against whole-body x irradiation by cysteamine, AET, and deep hypothermia, singly, and by a combination of cysteamine pretreatment and deep hypothermia. The different treatments were randomized among littermates to minimize animal variation. A comparison of the $LD_{50(30)}$ values obtained for the different treatments gave a dose-reduction factor of 3.3 for the combined treatment, which was significantly greater than the factor for hypothermia alone, 2.6, or that for cysteamine alone, 1.4. Cysteamine therefore provided additional protection in the fully hypoxic (hypothermic) animal. Judged from the histological appearance of the gonads of the surviving male nestling rats, killed 30 days after irradiation, hypothermia afforded some protection to the germinal epithelium. Cysteamine, although injected when the testes were abdominal, had no demonstrable protective effect. (auth)

**18077** STUDY OF THE RADIOPROTECTIVE EFFECT OF 5-METHOXYTRYPTAMINE ON HAEMOPOIETIC STEM CELLS. Feher, I.; Gidali, Julia; Sztanyik, L. (National Research Inst. for Radiobiology and Radiohygiene, Budapest). Int. J. Radiat. Biol., 14: 257-62(1968).

The radioprotective effect of 5-methoxytryptamine (Mexamin) was studied on the survival of colony-forming cells of mice. The exogenous method was used in the dose-range 195 to 389 Rads of $^{60}Co$ $\gamma$ irradiation, and the endogenous method in the range 486 to 925 Rads. The combination of the two methods made possible reliable determination of the radioprotective effect of Mexamin both in the low and high dose-range. The slope of the curves suggested that the radioprotective effect of Mexamin was not a simple dose-reduction effect. (auth)

**18078** TOTAL-BODY IRRADIATION OF CANINE LYMPHOMA. Johnson, Ralph E.; Cameron, Thomas P.; Kinard, Roy (National Cancer Inst., Bethesda, Md.). Radiat. Res., 36: 629-32(Dec. 1968).

The response of canine lymphoma to total-body x irradiation was examined and objective remissions of disease were observed. (auth)

**18079** EFFECTIVENESS OF HYPOGLYCEMIC AGENTS IN GUINEA PIGS EXPOSED TO MIXED GAMMA-NEUTRON RADIATIONS. Davis, Lawrence W.; Brown, James A.; Strike, Thomas A. (Armed Forces Radiobiology Research Inst., Bethesda, Md.). Radiat. Res., 36: 622-8(Dec. 1968). (UR-152-13).

The effect of 200, 1000, and 5000 rads of mixed gamma–neutron radiations on total blood reducing sugar and blood glucose levels in guinea pigs was investigated two and 24 hours, and nine, 22, and 60 days postirradiation. In addition, the effectiveness of insulin and tolbutamide in these animals was evaluated before and after irradiation. Glucose increased to a lesser degree and later than did the nonglucose fraction of the blood sugar. Insulin and tolbutamide were at least as effective in irradiated animals as in unirradiated ones except after 5000 rads, when tolbutamide was significantly less effective. These results suggested that: insufficient insulin was released by the pancreas in response to elevated blood sugar levels following irradiation; the pancreas did produce insulin at those times and was able to release it in response to tolbutamide; and a decrease in insulin production occurred following supralethal doses of radiation. (auth)

**18080** IRON-INDUCED PIGMENT FORMATION AND IONIZING RADIATION RESISTANCE IN THREE STRAINS OF MICROCOCCUS VIOLAGABRIELLAE. Bleviss, Morley; Weijer, J.; Payne, J. I. (Univ. of Alberta, Edmonton). Radiat. Res., 36: 454-69(Dec. 1968).

Three strains of Micrococcus violagabriellae — Littlepig, Pig (Parental), and Superpig — were studied. The pulcherrimin pigment (which imparts a violet-red color to the colonies of the Parental and Superpig strains) was produced only when the cells were grown in the presence of excess iron and provided a unique system for the study of the radioprotection conferred by a pigment. Cell suspensions of each of the three strains (initially grown in the presence and in the absence of excess iron) were exposed to gamma rays and plated on media containing an excess of iron and on media without iron. The survival curves of the treated strains indicated a correlation between the color intensity of the pigment (pulcherrimin), and the ability of the organisms to survive moderate doses of ionizing radiation. Studies using radioactive iron ($^{59}Fe$) showed that a correlation also existed between the intensity of the pigment and the amount of iron that the cells of each strain could remove from the medium. The effect of gamma irradiation on postirradiation cell growth was discussed for each strain irradiated during logarithmic growth and during a stationary state. (auth)

**18081** INFLUENCE OF CERTAIN RADIOPROTECTORS ON THE SENSITIVITY OF IRRADIATED ANIMALS TO BACTERIAL ENDOTOXINS. Pustovalov, Yu. I.; Zheludov, V. I. (Central Roentgenoradiological Scientific Research Inst., Leningrad). Radiobiologiya, 8: 876-9(1968). (In Russian).

The influence of cystaphos, aminoethyl isothiuronium, 5-methoxytryptamine, and combinations of cystaphos with 5-MOT on the change in the sensitivity of animals protected before x irradiation to endotoxin of Salmonella paratyphi B-42, was investigated. The experiments were conducted on 500 irradiated white mice protected by protectors and nonirradiated white mice, with a determination of $LD_{50/1}$ according to the method of Reed and

Muench. Chemical protection lowers the sensitivity of the irradiated mice to bacterial endotoxins in comparison with the unprotected control by 15 to 20 fold. Among the protected mice, their sensitivity to bacterial endotoxins is four to five times as high as that of nonirradiated animals and is maintained at this level up to the end of the autoinfectious period. (JPRS)

**18082** PECULIARITIES OF THE ACCUMULATION OF NEUTRAL RED UNDER THE INFLUENCE OF CYSTAMINE IN THE ORGANS OF IRRADIATED MICE DURING THE RECOVERY PERIOD. Zherebchenko, P. G.; Zaitseva, T. G. (Military Medical Academy, Leningrad). Radiobiologiya 8: 843-5(1968). (In Russian).

In the lungs of $\gamma$-irradiated mice during the recovery period, there is an increase in the accumulation of neutral red in comparison with nonirradiated animals. When cystamine is administered during this period of radiation sickness, the decrease in the accumulation of the dye during the early phase, characteristic of the action of this preparation, is weakly expressed, and the appearance of a late phase of increased content, which is absent in intact animals, is observed. The administration of cystamine before irradiation does not prevent changes in the accumulation of the dye in the lungs of mice during the recovery period. In the same period of radiation sickness, no significant changes in the accumulation of neutral red in the brain, associated with the action of radiation, were detected. (JPRS)

**18083** COMBINED USE OF CHEMICAL PROTECTORS AND LOCAL HYPOXIA IN THE PROPHYLAXIS OF RADIATION SICKNESS. Semenov, L. F.; Barkaya, V. S. (Inst. of Experimental Pathology and Therapy, Sukhumi, USSR). Radiobiologiya, 8: 917-19(1968). (In Russian).

In experiments on 1140 noninbred white mice the influence of local hypoxia on the course and outcome of acute radiation sickness and the possibility of combined application of local hypoxia and chemical protectors in the prophylaxis of radiation sickness was studied. The animals were irradiated with the $\gamma$ rays of $^{60}Co$, 60 to 70 R/min. The application of a rubber tourniquet on a limb of the animal 10 to 15 min before irradiation appreciably lessened the severity of radiation sickness at a dose of 920 R, had little effect at a dose of 1050 R, and did not protect the animals at all under conditions of injury by a superlethal dose of radiation (1125 R). The combination of cystamine (175 mg/kg) with local hypoxia substantially alleviated the outcome of radiation sickness in the case of absolutely lethal and superlethal doses of radiation (1050 and 1125 R), while the addition of mexamine (50 mg/kg) to local hypoxia was not accompanied by any intensification of the protective effect. (JPRS)

**18084** EFFECTS OF CERTAIN PROTECTORS ON THE SURVIVAL OF EMBRYOS AND THE VISCOUS PROPERTIES OF DNA IN THE CASE OF IRRADIATION OF LOACH SPERM. Vinogradova, I. D.; Shekhtman, Ya. L. (Inst. of Biological Physics, Pushchino on the Oka, USSR). Radiobiologiya, 8: 811-15(1968). (In Russian).

Cysteamine, cysteine, thiourea, AET, and ethanol were tested as protectors of loach sperm cells from x radiation according to the test of death of the embryos and according to the decrease in the viscosity of DNA. It was shown that: AET and cysteine do not give a protective effect on survival and DNA, both in vivo and in vitro; thiourea does not protect sperm cells according to survival rate of the embryos and viscosity of DNA, but it exhibits a high coefficient of protection when DNA is irradiated in solution; cysteamine protects sperm cells according to survival rate but does not give protection to DNA. At the same time, when DNA is irradiated in vitro it proves to be an effective protector. Ethanol proved to be a very effective protector. (JPRS)

**18085** TUBERCULIN SENSITIVITY AND LYMPHOGRANULOMATOSIS: ON THE INFLUENCE OF RADIOTHERAPY ON BLAST CELL TRANSFORMATION FROM LYMPHOCYTES IN CELL CULTURES FOLLOWING ADDITION OF TUBERCULIN WITH REGARD TO HISTOLOGICAL VARIATIONS AND THE CLINICAL STAGE OF LYMPHOGRANULOMATOSIS. Wuttke, Hermann; Haferkamp, Otto; Sobbe, Axel (Univ., Bonn). Strahlentherapie, 136: 454-7(Oct. 1968). (In German).

When compared to a group of healthy people, the blastcell transformation (transformation of bloodlymphocytes to blastcells in cell culture after addition of tuberculin) of five out of seven patients with Hodgkin's Disease was strikingly reduced. The remaining two patients (one with a negative tuberculin skin test) demonstrated no blastcell transformation at all after addition of tuberculin. In repeated cell cultures of blood samples collected during and after completion of X irradiation there was a distinct increase in the blastcell transformation. On the other hand the transformation of lymphocytes collected from healthy, unirradiated donors in a comparable interval showed no remarkable change (control 2). Likewise there was no blastcell transformation in cultures collected before, during and after radiotherapy when tuberculin was not added to the lymphocyte cultures (control 1). (auth)

# Radiation Effects on Animals

*Refer also to abstract 18040.*

## Invertebrates

*Refer also to abstracts 17966, 17967, 17992, 17993, and 18176.*

**18086** HOW DOES NUCLEAR RADIATION AFFECT HONEY BEES? Goolsby, Martha (Oak Ridge National Lab., Tenn.). Amer. Bee J., 108: 352-3(Sept. 1968).

The effects of various doses of cobalt-60 $\gamma$ irradiation and of fast neutrons on the survival and behavior of honey bees were studied under both laboratory and ecological conditions. The laboratory experiments using 5000 Rads showed a 29% decrease in life span but the field results showed that when an entire colony was irradiated the species perished. (F.M.M.)

## Vertebrates

*Refer also to abstracts 17893, 17910, 17912–17914, 17916–17920, 17925, 17933–17938, 17944, 17946, 17947, 17949, 17951–17953, 17957, 17958, 17996–17998, 18039, 18072, 18075–18077, 18079, and 18081–18084.*

**18087** (CEA-CONF-1172) EFFECTS OF RADIATION ON THE URINARY EXCRETION OF FREE AMINO ACIDS IN THE RABBIT. Valle, C.; Huet, J. C.; Marble, G. (Commissariat a l'Energie Atomique, Fontenay-aux-Roses (France). Centre d'Etudes Nucleaires). [nd]. 13p. (In French). (CONF-681013-12). Dep.

From 1st European Congress on Radiation Protection and Exhibition on Equipment Using Low Energy and Short Range Radiation Dosimetry, Menton, France.

The results obtained in the study of the urinary excretion of free amino acids in rabbits exposed to 400, 600, 800, and 1000 rads of $\gamma$ radiation from a $^{60}Co$ source were reported. Some results present analogies with those observed during accidental human irradiation. It is difficult to draw dose-effect relations of the results from this first study. (tr-auth)

**18088** (CONF-670503–, pp 39-45) EFFECTS OF RADIATION ON SURVIVAL OF WILD COTTON RATS (SIGMODON HISPIDUS) IN ENCLOSED AREAS OF NATURAL HABITAT. Pelton, Michael R.; Provost, Ernest E. (Georgia Univ., Athens).

Each month for four successive months four groups of wild adult female cotton rats (eight females per group) were irradiated at dose levels of 500, 750, 900, 1050, and 1200 R whole-body. Treatment was accomplished at 1.5 m using a 9200 Ci $^{137}Cs$ source at a rate of approximately 20 R per minute. Each group was released into a one acre enclosure with four unirradiated (control) females and four untreated males. Fifteen days later the animals were removed by live and/or snap trapping. Recapture and survival data on the females were subjected to analysis of variance for the effects of dose level and month, and a field $LD_{50}$ was determined. Results of these field experiments substantiate the high radioresistance determined for this species in previous laboratory experiments and suggest quantitative similarity and qualitative differences in stressors existing between the two environments. A direct correlation was established between dose level and survival with recaptures ranging from 91% at the 500 R level to 25% at 1200 R. Survival was essentially 100% among controls. No seasonal effects were noted in these experiments. (auth)

**18089** (CONF-670503–, pp 127-30) ENDOTHELIAL CELL AS AN INDICATOR OF ANIMAL RADIOSENSITIVITY. Cromroy, Harvey L.; Porter, A. H.; Burns, A. H.; Varnell, J.; Broce, A. (Florida Univ., Gainesville).

The columnar epithelial cells of the duodenal intestinal mucosa in mammals and the endothelial cells lining the mid-gut in insects were used as indicators of radiosensitivity. The nuclear volumes for eight species of insects and seven species of mammals were measured. The interphase chromosome volume (nuclear volume divided by diploid number of chromosomes) for each species was determined and plotted against its respective $LD_{50}$. The mammalian species have a positive slope whereas the insect species have a negative slope. The endothelial cell does appear to be feasible as an indicator cell for radiosensitivity. (auth)

**18090** (CONF-670503–, pp 131-41) INTERACTIONS OF IONIZING RADIATION, SALINITY, AND TEMPERATURE ON THE ESTUARINE FISH, FUNDULUS HETEROCLITUS. Angelovic, J. W.;

White, J. C. Jr.; Davis, E. M. (Bureau of Commercial Fisheries, Beaufort, N. C. Radiobiological Lab.).

The interactions of salinity, temperature, and ionizing radiation as environmental factors affecting the mortality, $LD_{50}$, and $^{22}Na$ efflux of the euryhaline fish, Fundulus heteroclitus, were determined in a series of experiments. Multiple regression analyses were used to derive equations describing the effects of all factors that had a significant effect on mortality of the fish at three different intervals after irradiation. The effects of temperature were significant at all three intervals, and the effects of salinity, radiation dose, and the temperature-salinity interaction were each significant at one or more of the different times after irradiation. Various combinations of different levels of temperature and salinity yielded different $LD_{50}$ values. At the upper end of their temperature range, the fish tolerated more radiation at low salinity. At the lower end of their temperature range this tolerance was reversed. Irradiated fish generally lost $^{22}Na$ more rapidly than unirradiated fish suggesting the lethal effects of radiation may stem from damage to osmoregulatory capabilities. (auth)

**18091** (CONF-670503-, pp 152-6) EFFECT OF SUBLETHAL GAMMA IRRADIATION ON THE IRON METABOLISM OF THE PINFISH, LAGODON RHOMBOIDES. Engel, David W. (Bureau of Commercial Fisheries, Beaufort, N. C. Radiobiological Lab.).

The effect of acute irradiation on iron metabolism of the pinfish, Lagodon rhomboides, was investigated by measuring the specific activity of injected $^{59}Fe$ in the blood and tissues of irradiated and unirradiated fish. A radiation dose of 2000 rads markedly disrupted iron metabolism. Decreased specific activity of the blood for more than 22 days in the irradiated fish indicated depressed erythrocyte production; increased specific activity above the level of the controls on the 36th day indicated recovery of erythropoiesis. Changes in the specific activity of the kidney and spleen after irradiation suggested that the kidney was the major erythropoietic organ and that the spleen had no more than a minor role in erythrocyte production. Changes in the specific activity of the liver suggested that it functioned only in iron storage and mobilization. (auth)

**18092** CHANGES IN THE SKIN IN THE AREA OF REPEATED BURNS IN ANIMALS EXPOSED TO IONIZING RADIATION. Maisyuk, A. P.; Komendantova, A. L.; Botsmanov, K. V. Eksp. Khir. Anesteziol., 11: 74-5(Sept.-Oct. 1966). (In Russian).

Second and third degree burns over 10% of the body surface of experimental animals were obtained using a magnesium spark following 20 days exposure to 400 and 600 R of ionizing radiation. The data showed nutritional disturbances in the tissues, disturbances in mechanisms regulating regenerative processes, the appearance of epithelial hyperplasia, hyperkeratosis, and papillae, and the formation of nodules and connective tissue cords. Control animals exposed to second and third degree burns did not show corresponding changes in the skin. (R.V.J.)

**18093** THE FECUNDITY OF A GAMBUSIA AFFINIS AFFINIS POPULATION EXPOSED TO CHRONIC ENVIRONMENTAL RADIATION. Blaylock, B. G. (Oak Ridge National Lab., Tenn.). Radiat. Res., 37: 108-17(Jan. 1969).

The fecundity of Gambusia affinis affinis, the common mosquito fish, that has inhabited a lake contaminated with radioactive waste for over one hundred generations, was compared with a control population. The calculated dose rate from the bottom sediments to the Gambusia population in this contaminated environment was 10.9 rads/day. A significantly larger brood size occurred in the irradiated than in the nonirradiated population, although significantly more dead embryos and abnormalities were observed in the irradiated broods. These results suggest that an increased fecundity is a means by which a natural population of organisms having a relatively short life cycle and producing a large number of progeny can adjust rapidly to an increased mortality caused by radiation. (auth)

**18094** PENETRATION AND RETENTION OF TETRACYCLINE IN A FOCUS OF DEVELOPING CLOSTRIDIAL MYONECROSIS IN AN IRRADIATED ORGANISM. Konecny, B.; Petyrek, Voj. Zdravot. Listy, 37: 65-7(Apr. 1968). (In Czech).

Experiments conducted on non-irradiated and irradiated guinea pigs are described; the irradiation was effected by a whole-body dose of 300 R. Tetracycline (TTC) was administered as a single dose intramuscularly into the focus of a clostridial myonecrosis during various stages of its development. In irradiated animals the retention of TTC in the focus of the myonecrosis was reduced. This is one of the causes of reduced effect of TTC administration to irradiated animals with clostridial myonecrosis. (JPRS)

**18095** ON THE EFFECT OF $^{60}Co$ IRRADIATION ON THE MYCOSIS ATTACK BY INOCULATING ETIOLOGICAL FILAMENTOUS FUNGI INTO STOMACH CAVITY. Chiba, Keiko (Yokohama City Univ., Japan). Yokohama Igaku, 19: 81-9(Mar. 1968). (In Japanese).

The systematic development of Aspergillus and Mucor infections in mice that were weakened by $^{60}Co$ irradiation was investigated. Inoculation of the gastral cavity with spores was used to induce infection. Infection increased in the following order: lung, intestines, spleen, liver, kidneys, brain, and heart. The blood picture was also followed and the results are described. (NSA of Japan) (TSS)

**18096** THE ACTION OF X-IRRADIATION ON THE REGENERATION FIELD OF THE ADULT NEWT, DIEMICTYLUS VIRIDESCENS. Colville, Jean Ellen. New Orleans, Tulane Univ., 1968. 61p.
Thesis.

Right forelimbs were irradiated with 2,000 R x radiation. Right and left forelimbs were then parabiosed along their posterior edges and were amputated. These grafts were of four types: parallel, acute, right, and obtuse, depending upon the angles which the stumps made with each other. Forelimbs of control animals underwent similar grafts in which both limbs were unirradiated. The cartilage patterns in the control and experimental groups were compared at 60 days post-amputation. Sham operations were performed on irradiated and unirradiated limbs in order to determine the effects of the operative procedures on the regenerative capacity. In the control series, the interference effects resulting from the longitudinal lines of control in the stump were evident. As the angle between the stumps was increased, the number of digits in the bilaterally symmetrical regenerates decreased. Parallel stumps produced regenerates consisting of two hands. At wider angles, the more central structures were eliminated, until, at very wide angles, the doubled stumps produced no regenerates. In the experimental series, there were no interference effects from the irradiated right forelimbs. Most regenerates that were produced consisted of single normal asymmetric left hands. There was no decrease in the number of digits, despite widening angles between the stumps. Animals that had undergone sham operations showed no variation from the normal pattern of regeneration. Irradiated limbs produced no regenerates in 97.7% of the cases, while unirradiated limbs regenerated normally in 91.1% of the cases. X rays seem to act on the limb to eliminate the interference effects normally found in regenerating doubled stumps. This seems to involve a disruption of the longitudinal control of the regeneration field. The loss of inter-tissue communication and possible loss of the bioelectric field in irradiated limbs is discussed. (Diss. Abstr.) (TSS)

**18097** EFFECT OF BONE MARROW PROTECTION ON THE CELLULAR COMPOSITION OF IRRADIATED MOUSE THYMUS. Blomgren, H.; Revesz, L. (Karolinska Institutet Medical School, Stockholm). Exp. Cell Res., 53: 261-71(Oct. 1968).

The cellular depletion and repopulation pattern of the mouse thymus were analyzed after irradiation of mice with different doses of x radiation. The whole body was exposed or a part of the bone marrow was shielded during treatment. The volume as determined by an electronic particle analyzer was used as a specific marker characteristic of the different cell classes. Partial protection of the bone marrow during irradiation inhibited the decrease of the thymus cell population, accelerated the repopulation of the organ, and inhibited the secondary depletion which characterizes the response of irradiated thymus in unprotected mice. These effects of a partial bone marrow protection were associated with a predominance of large-size cells in the thymus cell population at corresponding periods after irradiation. The repopulation pattern of large- and small-size cells showed characteristic differences in both protected and unprotected animals. The repopulation of small cells was continuous, and that of the large cells was characterized by a phase of deceleration 5 to 8 days after irradiation. The increase of the total population was associated with an increase in the relative number of cells with large size, while the decrease of the population with a predominance of cells with small size. The relevance of the observation in indicating the origin of small-size cells from large-size cells, and the source of the repopulating cells from a pool of survivors in the thymus and/or stem cells migrating from the protected bone marrow, is discussed. (auth)

**18098** CIRCULATING ANTIDIURETIC HORMONE IN THE X-IRRADIATED RAT. Vierling, Anton F.; Radford, Edward P. Jr.; Little, John B. (Harvard School of Public Health, Boston. Univ. of Cincinnati). Radiat. Res., 36: 441-53(Dec. 1968).

Male rats exposed to 500 R of whole-body x irradiation were allowed food and water ad libitum and housed in metabolism cages; water and food intake and urinary and fecal excretion were recorded daily. Urine output increased 200% during the first 24 hours after irradiation. No significant changes occurred in daily sodium,

potassium, urea, or total solute excretion, although calcium excretion approximately doubled after irradiation. The marked increase in free water excretion implicated antidiuretic hormone (ADH) in this phenomenon. Application of a sensitive bioassay for ADH permitted measurement of plasma ADH concentrations in undisturbed, unanesthetized rats before and after irradiation. ADH levels were lower and frequently not detectable 24 hours after exposure. High ADH levels, however, could be provoked in irradiated rats by hemorrhage, indicating that the receptor cells and secretory ability of the posterior pituitary remained intact. Furthermore, irradiated rats responded normally to small intravenous injections (4 to 8 μU) of exogenous ADH. Rats with congenital diabetes insipidus given daily injections of Pitressin showed no postirradiation diuresis. Lastly, increased urinary calcium excretion could result from hypercalcemia which was known to induce diuresis through calcium–vasopressin antagonism. These results further suggested that the diuretic response was due to decreased circulating ADH. (auth)

**18099** EFFECT OF CYCLOPHOSPHAMIDE ON HEMATOPOIETIC STEM CELLS. Fried, W.; Johnson, C. (Veterans Administration West Side Hospital, Chicago. Univ. of Illinois, Chicago). Radiat. Res., 36: 521-7(Dec. 1968).

The effects of cyclophosphamide on hematopoietic stem cells (HSC) and on hematopoiesis were studied. Administration of 5 mg of cyclophosphamide to mice resulted in a rapid decrease in the number of HSC in the leg and spleen. The exocolonizing potential of HSC in the spleen of x-irradiated mice recovered and reached supranormal levels in seven days. That of HSC in the legs recovered to pretreatment values after 15 days. The endocolonizing potential of HSC in the leg, however, recovered in less than four days. The peripheral blood counts all dropped to a fraction of normal except for the platelet count, which was affected to a minimal degree. It was suggested that cyclophosphamide irreparably damaged most of the body's HSC. Those remaining in the leg then proliferated rapidly and repopulated other sites. HSC could not, however, accumulate in the leg for more than a week after cyclophosphamide administration. Erythropoiesis did not recover until after this occurred. Platelets were least affected because of their resistance to the effects of the drug and because of the ability of megakaryocytes to increase their output of platelets without requiring differentiation of HSC into their compartment. (auth)

**18100** EFFECTS OF PRENATAL X-IRRADIATION: STUDIES ON THE MECHANISM OF X-IRRADIATION-INDUCED INHIBITION OF MICROSOMAL ENZYME DEVELOPMENT IN RAT LIVER. Nair, V.; Bau, D.; Siegel, S. (Chicago Medical School). Radiat. Res., 36: 493-507(Dec. 1968).

Exposure of pregnant rats to 25 R of x irradiation on the fourteenth gestation day produced in the male offspring an impairment of the development of the hepatic microsomal enzyme system which metabolizes hexobarbital. However, irradiation did not suppress the increase of enzyme activity brought about by the administration of chemical inducers (phenobarbital). Actinomycin, on the other hand, inhibited to varying degrees both the ontogenic and phenobarbital-induced increases in enzyme activity. The effects on the enzyme system were supported by in vivo measurements of the duration of hexobarbital hypnosis. The ontogenic increase in enzyme activity was hormone-dependent, while that following phenobarbital administration was independent of hormonal regulation as evidenced by the response in hypophysectomized or sexually immature animals. It was concluded from these results that the inhibitory effect of x irradiation on the hepatic enzyme system was mediated through an action on the hormonal regulation of enzyme activity. Evidence for this hypothesis was discussed. (auth)

**18101** RADIOSENSITIZING MECHANISM OF MONOIODOACETIC ACID. Grigoresco, St.; Nedelco, C.; Nastase, M. (Centre de Radiobiologie et de Biologie Moleculaire, Bucharest). Int. J. Radiat. Biol., 14: 197-206(1968). (In French).

To obtain additional information on the mechanism of radiosensitization by monoiodoacetic acid, the following investigations were performed: The action of monoiodoacetic acid on the local irradiation of Jensen sarcoma. The incorporation of $^{131}I$ monoiodoacetic acid in rats carrying the Jensen sarcoma. The action of monoiodoacetic acid on the incorporation of different $^{14}C$-labeled aminoacids (alanine, arginine, valine). The action of monoiodoacetic acid on the $O_2$ consumption and Hb/MetHb equilibrium of red cells in rats. The results obtained revealed that the radiosensitizing effect of monoiodoacetic acid on Jensen sarcoma was followed by a decrease in incorporation of $^{14}C$-arginine and $^{14}C$-valine in tumor tissue and also by an increase in oxygen consumption by the red cells. It seemed that the monoiodoacetic acid, which in vivo reacted preferably with SH-containing molecules, might also interact with $NH_2$-containing molecules. (auth)

**18102** SEVERE FIBROSIS OF THE SKIN AND SUB-DERMAL TISSUE OF GOATS AFTER SINGLE EXPOSURES TO FAST NEUTRONS. Edmondson, P. W. (Medical Research Council, Harwell, Eng.). Int. J. Radiat. Biol., 14: 263-70(1968).

Three to five months after single exposures to fission neutrons, 620 to 787 Rads, goats developed massive fibrosis of the dermis and the underlying connective tissue and muscles. Immobilization of limbs was a common complication. Clinically the lesions appeared to be similar to those seen in man after neutron therapy, but in both evolution and histology they differed significantly from human radiodermatitis. They have not been described in other animal species. (auth)

**18103** STRAIN DIFFERENCES IN RADIOSENSITIVITY OF MICE AS PREDICTED FROM THE FLUCTUATION OF PHYSIOLOGICAL FUNCTIONS. Ueno, Yori (Kyoto Univ.); Pospisil, M. Nippon Igaku Hoshasen Gakkai Zasshi, 26: 1508-10(Feb. 1967).

It was previously reported that the degree of homeostatic fluctuation of a chosen parameter, such as the body weight or the Na/K ratio in the urine of mice, was related to the radiosensitivity of individuals of the same strain. It was investigated whether this relationship could also be applied for explaining the different radiosensitivities of various strains of mice. The following strains of mice were used: CBA-, C57BL/6, dd/YF and CF-1. On the basis of literary data, $LD_{50}$ approximately 750 to 800 R for CBA-strain, about 630 R for C57BL/6-strain, 600 R for dd/YF-strain and 525 R for CF-1-strain were used. Then, the degree of homeostatic fluctuation of the body weight was determined for the individual animals by the Mean Square Successive Difference method and expressed as the value of $\delta^2$. The mean value $\delta^2$ of the entire experimental complex corresponded to 0.55, irrespective of the strain used. Around this value the middle fluctuation of physiological functions could be observed, and according to the previous results, the individuals with a high radioresistance were found. The individuals with a $\delta^2$ value from 0.40 to 0.70 were marked as theoretically radioresistant. The percentage of theoretically radioresistant individuals in the strains was compared with the $LD_{50}$ data for these strains. It was shown that the percentage of radioresistant individuals was proportionate with the presumed value of $LD_{50}$. Therefore, it seemed that the chosen indicator for the physiological state of an individual could also be applied to the genetically conditioned interstrain differences in radiosensitivity. (NSA of Japan)

**18104** BIOLOGY OF RADIATION INJURY. THE PROCESS OF AND RECOVERY FROM RADIATION INJURY IN CELL POPULATIONS. Egami, Nobuo (National Inst. of Radiological Sciences, Chiba, Japan). Kagaku To Seibutsu, 6: 25-30(Jan. 1968). (In Japanese).

Killifishes reared in water of 23°C were subjected to whole-body $^{60}Co$ γ irradiation, and the effects of fractionation and temperature were studied. The results obtained are as follows: In a single irradiation with 4.8 kR killifishes all died after about 10 days. When the dose was divided in five with 0.96 kR daily, only few killifishes died after 30 days. When killifishes were kept in water of 6°C during the five days of fractionated irradiation, they all died after 30 days, showing a disappearance of the effect of fractionation. When 4.8 kR was received within 8 hours, killifishes all died after 30 days. When 4.8 kR was received over 96 hours, few fishes died after 30 days. When this low dose-rate irradiation was made in water of 6°C, killifishes all died after 30 days, showing a disappearance of the effect of low dose-rate. From the above results and other available information, the following conclusions were possible. When the living body was exposed to radiation, the intracellular critical structure (DNA) was first damaged, and retardation, abnormality and arrest of cell divisions resulted in critical organs (hematopoietic tissues and intestinal epithelium). Then, functioning of the cells of critical organs decreased and the individual died. Two factors were possibly involved in the effect of fractionation: one was that the second irradiation coincided with the radioresistant time of the cell cycle and the lethal effect was reduced; and the other was the increase of new cells owing to the regeneration of tissues irrespective of the cell cycle. The proliferation of new cells did not take place at a low temperature of 4 to 6°C. Thus the above results suggested the existence of the regeneration of tissues. In the recovery from radiation injuries, there seemed to be two processes, namely, the increase of regenerating new cells and the intracellular repair following immediately after irradiation. (NSA of Japan)

**18105** THE QUANTITATIVE ANALYSIS OF RADIATION EFFECT OF 200 KVP X-RAYS, $^{60}Co$ GAMMA RAYS, 15 MV X-RAYS AND 15 MeV ELECTRON BEAMS. Koga, Mitsuru (Kyushu Univ., Japan). Fukuoka Igaku Zasshi, 59: 309-25(1968). (In Japanese).

The biological effects of four different radiations (200 kVp

x rays, $^{60}$Co γ rays, 15 MV x rays and 15 MeV electrons) were studied using weight and nucleic acid content of the spleen and thymus of $CF_1$ male mice as indicators. The spleen and thymus were taken three days and a half after irradiation; the weight of these organs was measured by a chemical balance; the nucleic acid was extracted by modified Schneider's method, and quantitative analysis of DNA was made with Diphenilamin reaction, and analysis of RNA was made with Orcin-HCl reaction. Irradiation was calibrated by a Victoreen chamber. The values lay nearly on a straight line between 125 and 800 Rads on semilogarithmic scale. From these data a regression line was obtained. Comparison was made on the ratio of the dose under a constant effect and the ratio of effect under a constant dose. The former calculation was made on 40, 50 and 60% decreases in the weight and nucleic acid contents, and the latter calculation was done on 300, 400, 500 and 600 Rads. The values for equal effect ratio of 50% effects were given for spleen for the four different radiations. Similar values were obtained on the thymus, so was the equal dose ratio when the values were compared with a constant dose. The results suggested that there was a close relation between the equal effect ratio and LET, and that LET value in this report could be more properly calculated according to δ-track by Burch than by Gray. (NSA of Japan)

**18106** A QUANTITATIVE STUDY OF THE LEUKEMOGENIC ACTION OF WHOLE-BODY X-IRRADIATION AND URETHANE. II. IN NEWBORN C57BL MICE. Chen, Louise; Berenblum, I. (Weizmann Inst. of Science, Rehovoth, Israel). Israel J. Med. Sci., 4: 1164-8(Nov.-Dec. 1968).

Newborn and suckling C57BL mice exposed to a single or repeated doses of 50 R whole-body x-irradiation failed to develop leukemia later in life; those exposed to four weekly doses of 150 R did develop leukemia, but with an incidence no higher than that obtained in adults subjected to the same treatment. Newborn mice did not, therefore, seem to be hypersensitive to radiation leukemogenesis as they are to urethane leukemogenesis. The responses of newborn and suckling mice to urethane injections were as follows: One i.p. injection of urethane (1 mg/g body weight) administered within 20 hr of birth failed to induce leukemia, but two weekly injections were effective, and three even more so, though additional weekly injections failed to raise the incidence further. With three weekly injections the incidence of leukemia was highest when treatment was started within the first four days; the incidence fell off when the first injection was given seven or 14 days after birth; it reached zero when the first injection was given 21 days after birth. The results are discussed in relation to the known rates of catabolism of urethane in newborn and adult mice. (auth)

**18107** A QUANTITATIVE STUDY OF THE LEUKEMOGENIC ACTION OF WHOLE-BODY X-IRRADIATION AND URETHANE. I. IN ADULT C57BL MICE. Berenblum, I.; Chen, Louise; Trainin, N. (Weizmann Inst. of Science, Rehovoth, Israel). Israel J. Med. Sci., 4: 1159-63(Nov.-Dec. 1968).

Leukemia induction in C57BL mice by the two-stage technique, using whole-body x-irradiation as initiator and urethane injections as promoter, was reexamined under varying conditions of dosage and length of treatment. By limiting the radiation to a single exposure, background leukemogenesis was reduced almost to that of the spontaneous incidence. The effectiveness of x-irradiation (single exposure) for initiating action was manifested as a progressive rise in leukemogenesis with increasing dose, when adequate urethane was given after it; while that of urethane, for promoting action, expressed itself as optimal activity reached after five weekly injections. Of the two age groups tested, the younger mice (28 to 32 days old) were more responsive than the older (37 to 44 days). (auth)

**18108** MECHANISM OF RADIATION ACTION IN LEUKEMOGENESIS. III. THYMOLYTIC EFFECT INDUCED BY THE LEUKEMOGENIC AGENT. Haran-Ghera, N. (Weizmann Inst. of Science, Rehovoth, Israel). Israel J. Med. Sci., 4: 1169-80 (Nov.-Dec. 1968).

Inoculation of a leukemogenic filterable agent, prepared from irradiated tissues of C57BL/6 mice, into growing (six-day-old) or mature (30-day-old) thymus grafts implanted under the kidney capsule of normal or irradiated hosts exerted a focal thymolytic effect on the thymocytes in the cortex. Recovery of the depleted grafts following inoculation with the leukemogenic agent was observed within 50 days after agent inoculation in the nonirradiated hosts only. In irradiated mice, susceptible to lymphoma development, the depleted grafts did not increase in weight before malignancy was observed. The thymolytic effect was shown to be specific, since no effect was observed when the agent was tested on spleen implants under the kidney capsule. The thymolytic effect of the leukemogenic agent on the thymus in situ was also demonstrated in thigh-shielded irradiated mice by successfully altering the characteristic thymus regeneration pattern, following i.v. inoculation of the agent five days after termination of the radiation procedure. (auth)

**18109** RESPONSE OF SIALADENOTROPHISM TO X-RADIATION: RADIOSENSITIVITY AND RECOVERY OF DIFFERENTIATED SALIVARY ACINAR CELLS. Van Den Brenk, H. A. S. (St. Thomas' Hospital, London). Int. J. Radiat. Biol., 14: 281-6 (1968).

The recovery pattern in salivary acinar cells of rats following split-doses of x irradiation was investigated. Rapid growth (sialadenotrophism) was induced in the salivary glands by isopropyl-nonadrenaline and the effects of different radiation doses on growth were determined. (F.M.M.)

**18110** ENDOGENOUS INFECTION IN RATS TREATED WITH $^{210}$Po AND $^{144}$Ce. Shal'nova, G. A. (Inst. of Biophysics, Moscow). Radiobiologiya, 8: 867-71(1968). (In Russian).

In experiments on 170 rats the development of enteric infections (the presence of intestinal microbes in the internal organs) was studied in the rats under the influence of administration of $^{210}$Po (0.005 μCi/g) and $^{144}$Ce (0.7 μCi/g). Among the treated rats, together with the detection of Escherichia coli in the blood, spleen, kidneys, liver, and mesenteric ganglion, higher titers of natural antibodies in the blood for typhoid and paratyphoid antigens were noted. The autoinfectious process is more pronounced after the administration of $^{210}$Po than after the administration of $^{144}$Ce. (JPRS)

**18111** LEVEL OF FREE FATTY ACIDS IN THE BLOOD SERUM OF RATS AFTER X-IRRADIATION. Levitskii, A. P. (Medical Inst., Odessa). Radiobiologiya, 8: 923-4(1968). (In Russian).

The free fatty acid (FFA) content in the blood serum of white rats, when determined by the colorimetric method of Konitzer et al., proved equal to 0.39 ± 0.027 μmole/ml. One day after 600 R of whole-body x irradiation, the FFA level was almost halved, after ten days it was higher than normal (however, $P > 0.05$), and on the 30th day after irradiation, it again was less than half the initial level. (JPRS)

**18112** SOME MORPHOLOGICAL AND FUNCTIONAL CHANGES IN DOGS IN THE LONG-TERM PERIODS AFTER ACUTE RADIATION SICKNESS. Chebotarev, E. E.; Genis, E. D.; Kerova, N. I.; Tolmacheva, E. G. (Inst. of Physiology, Kiev). Radiobiologiya, 8: 850-8(1968). (In Russian).

Two to three years after a single whole-body x irradiation at a dose of 600 R, among dogs surviving acute radiation sickness, no complete restoration of the investigated indexes was observed. In a study of the restoration of hemopoiesis, a more rapid normalization of the red blood cells was noted. The restoration of leukopoiesis was slower and was not entirely completed two to three years after irradiation. Complete normalization of the sugar-regulating function of the liver was not observed two to three years after irradiation. In the investigated endocrine glands, two or three years after irradiation, stable destructive and sclerotic processes accompanied by a decrease in their functional activity was observed. In the hypothalamo-pituitary system, degenerative and sclerotic processes that increased with time were detected, along with the absence of any difference in the neurosecretory cycle in the neurosecretory nuclei of the anterior hypothalamus. (JPRS)

**18113** MECHANISMS OF THE REACTION OF THE ADRENAL CORTEX IN RATS TREATED WITH $^{210}$Po. Moroz, B. B.; Pinelis, V. G. (Inst. of Biophysics, Moscow). Radiobiologiya, 8: 846-9(1968). (In Russian).

In acute and subacute radiation sickness among rats, induced by $^{210}$Po α and γ, the adrenocorticotropic activity of the peripheral blood, the response of the adrenal cortex to ACTH, and the activity of $NADPH_2$-diaphorase (histochemically) were studied in slices of adrenal cortex. The experiments indicated a distinct parallelism between the ACTH content in the blood and the amount of corticosterone in the adrenals. Exhaustion of the function of the adrenal cortex in the late period of radiation sickness (subacute form) is associated not only with a deficiency of endogenous ACTH, but also with blockage of the enzymes that participate in the biosynthesis of steroid hormones. (JPRS)

**18114** CHANGES IN THE ENTEROCHROMAFFIN CELLS OF THE INTESTINES IN RATS DURING THE EARLY PERIODS AFTER IRRADIATION. Pankratova, G. G.; Chernov, G. A. (Inst. of Biophysics, Moscow). Radiobiologiya, 8: 822-4(1968). (In Russian).

Gamma radiation at doses of 600 and 900 R leads to a transitory (up to 12 hrs) decrease in the enterochromatin cells in the mucous membrane of the intestines of rats. After 12 hrs, a restoration of the number of cells and their granulation to the

normal level was observed. Irradiation at a sublethal dose (300 R) did not produce any changes in the state of the enterochromatin cells. The greatest disturbances, as well as death of the cells, were detected in the case of irradiation at a dose of 3000 R. (J PRS)

**18115** PECULIARITIES OF THE BIOLOGICAL EFFECTS OF RADIOACTIVE ISOTOPES. Moskalev, Yu. I.; Strel'tsov, V. N. (Inst. of Biophysics, Moscow). Radiobiologiya, 8: 825-9 (1968). (In Russian).

Data are presented on the comparative biological effects of radioactive isotopes, ($^{144}$Ce, $^{140}$La, $^{90}$Y, $^{91}$Y, $^{89}$Sr, $^{90}$Sr, and $^{140}$Ba) possessing various types of radiation and effective half-lives. The frequency of appearance of osteosarcomas and leukemias in rats per unit dose of irradiation was estimated in the case of injury by various amounts of $^{90}$Sr. It was shown that among rats the frequency of leukemias per unit dose of irradiation increased 29-fold (from 0.000285 to 0.0083% per rad) when the total dose decreased 35-fold (from 18.6 to 0.53 krad). The factors lying at the basis of this observation are discussed. (J PRS)

**18116** EFFECTS OF HYPEROXYGENATION AND RADIATION ON GROWTH OF MALIGNANT TUMORS. Jona, Gabor; Miltenyi, Laszlo; Levai, Geza; Szilagyi, Tibor (Univ., Debrecen, Hungary). Strahlentherapie, 136: 468-71(Oct. 1968). (In German).

In an earlier publication studies with localized and generalized hyperoxygenation and irradiation of animals were reported. From further histological studies, it seemed that there was no notable difference between oxygen and peroxides, as far as tumor response was concerned. Recombination of the active radical of the peroxides must occur through the catalase of the serum, within the vascular lumen and near the injection site. The oxygen then went further as a solute in the plasma. These results and hypotheses were further confirmed with an immunobiology method. (auth)

**18117** PATHOGENESIS OF HYPERTENSION AND PATHOLOGIC CHANGES IN EXPERIMENTAL RENAL IRRADIATION. Fisher, Edwin R.; Hellstrom, H. Richard (Univ. of Pittsburgh). Lab. Invest., 19: 530-8(Nov. 1968).

The latent period for development of hypertension was shorter and the degree of blood pressure elevation was greater in rats in which total renal mass was irradiated than in those in which unexposed kidney was also present. This relation, the slight rebound in blood pressure following amelioration of hypertension by extirpation of irradiated kidneys, and results of estimates of juxtaglomerular and zona glomerulosa indices in rats with irradiation hypertension all coincided with findings observed in renovascular hypertension in this species. The kidneys of rats with irradiation hypertension exhibited variable ischemic and vascular changes. However, so-called irradiation sclerosis or contraction of the kidney was, with rare exception, encountered only in hypertensive rats in which arteriolonephrosclerosis was also conspicuous. A similar spectrum of parenchymal alterations also was observed in kidneys of rats with renal artery constriction. Pressor responses to angiotensin and renin were comparably increased prior to development of hypertension in rats subjected to unilateral renal artery constriction and in those in the latter stages of the prehypertensive latent period following bilateral renal irradiation when parenchymal or vascular alterations were not evident. Anatomical evidence of increased vascular sensitivity induced by renal irradiation was provided in this study by the occurrence of more severe vascular alterations in irradiated clipped kidneys of rats with renovascular hypertension and in kidneys from animals with deoxycorticosterone acetate-induced hypertension than in nonirradiated controls, although the degree and course of these forms of experimental hypertension were unaffected by renal irradiation. Although these observations do not preclude a direct cytotoxic effect of irradiation on renal tissue, they suggest that its biologic manifestations, namely, hypertension and renal parenchymal damage, may be pathogenetically related to early functional and subsequent anatomical vascular changes, the latter being related to or resulting from the hypertension. (BBB)

**18118** EFFECT OF IONIZING RADIATION ON CONNECTIVE TISSUE COMPONENTS. Bailey, Allen J. (Cambridge Univ., Eng.). Int. Rev. Connect. Tissue Res., 4: 233-81(1968).

The following topics are reviewed: interaction of ionizing radiation with matter, absorption of energy, measurement of radiation, radiolysis of water, distinction between direct and indirect effects; irradiation of fibrous connective tissue and effect of radiation on proteins, collagen, reticulin, and elastin; irradiation of ground substance (nature of ground substance and irradiation of polysaccharides); irradiation of cellular components; aging and irradiation; and chemical protection of tissues against radiation. Connective tissue is among the most radiation-resistant components of the body. The change in morphological appearance of the skin following irradiation in vivo requires large doses, >1500 rad. The in vitro irradiation of the individual components requires many times this dose, about 10 Krad to produce observable effects in solution and even higher doses (0.1 Mrad) in the fibrous state. Similarly, except for the permeability studies, detectable changes in properties of ground substance mucopolysaccharides require doses of a few Krad. The nature of the interactions of radiation and collagen, resulting in peptide bond scission and formation of a new type of intermolecular cross-link, has barely begun to be understood. Most collagen studies are of interest to leather and food scientists, but until changes can be detected at much lower doses, the usefulness to radiotherapeutics is limited. Elastin, owing to its insolubility, has been little studied. The importance of chemical protection and the repair of damaged molecules of connective tissue components are also considered. (BBB)

**18119** A COMPARISON OF THE EFFECTS OF IONIZING RADIATION AND RADIOMIMETIC DRUGS ON THE INTESTINAL EPITHELIUM. Hampton, James C. (Northwestern Univ. Medical School, Chicago). Atti Accad. Med. Lombarda, 21: 214-15(July-Sept. 1966).

The possibility that radiation effects are not limited to inhibition of cell proliferation and that postmitotic cells might also be damaged was tested with colchicine in mice. Although the proliferative compartments of the intestinal crypts were nearly destroyed, the villi did not show the extreme shortening obtained with x rays nor did villus cells develop degenerative cytologic changes. Villus cells at 4 days were still able to absorb and transport lipid. Irradiated cells showed greatly impaired absorptive and transport capabilities. Mitotic arrest was not an acceptable explanation for epithelial loss at 3 to 5 days postirradiation with 3 KR of x rays. Cells which were post mitotic and on the villus at the time treatment was started with colchicine were able to remain there for an extended period beyond their normal life span but were not able to do so in mice treated with x rays and with nitrogen mustard. Coding sites for the synthesis of messenger RNA would be available after either x irradiation or nitrogen mustard treatment. Interference with DNA-directed synthesis would be required in order to account for ribosome depletion and rapid epithelial loss following treatment with either x irradiation or nitrogen mustard. Crypt cells, primarily Paneth cells, also showed severe damage in both irradiated and nitrogen mustard-treated animals but, unlike the villi, no denuded areas in the crypts were found. (BBB)

## Man

*Refer also to abstracts 18072, 18073, and 18085.*

**18120** (CEA-CONF-1174) CHANGES IN THE URINARY EXCRETION OF AMINO ACIDS IN A CASE OF ACUTE WHOLE-BODY IRRADIATION. Marble, G.; Jammet, H. (Commissariat a l'Energie Atomique, Fontenay-aux-Roses (France). Centre d'Etudes Nucleaires). [nd]. 15p. (In French). (CONF-681013-11). Dep.

From 1st European Congress on Radiation Protection and Exhibition on Equipment Using Low Energy and Short Range Radiation Dosimetry, Menton, France.

The urinary excretion of free amino acids was determined after the accidental exposure of a technician to whole-body irradiation by $\gamma$ rays and neutrons. The qualitative and quantitative determination of the free amino acids was done by automatic chromatographic analysis. The amino acids were first fixed on the resin then progressively eluted by a continuous gradient of decreasing acidity. The continuous potentiometric recording of the optical density of the eluant, after reaction with ninhydrin allowed the quantitative evaluation of the amino acids. Urinary excretion curves for the amino acids were given in the form of cumulative excretion curves for the first six days following exposure. Leucine, alanine, phenylalanine, arginine, valine, and glucosamine, methionine, cysteic acid, cystine, proline, hydroxyproline, and $\beta$-aminoisobutyric acid maintained normal excretion rates. The excretion rates of serine, threonine, ethanolamine, and tyrosine were reduced. The excretion rates of glutamic acid, aspartic acid, $\alpha$-aminobutyric acid, ornithine, and taurine were sharply increased. (J.S.R.)

**18121** RADIATION PROTECTION AND URANIUM MINING. Tompkins, Paul C. (Federal Radiation Council, Washington, D. C.). J. Occup. Med., 10: 702-6(Dec. 1968).

The validity of relating the observed excess of lung cancers in uranium miners to exposure to radon daughters alone is discussed. The isotopes of primary concern were $^{214}$Bi, $^{214}$Pb, $^{214}$Po, and $^{218}$Po. The primary problems at this time are working out the combination of environmental controls, dosimeter usage, occupancy records, and possibly respirators for underground protection. Successful protection of the uranium miner depends

strongly on periodic medical examinations, a more detailed knowledge of the mine environment, and greater use of indicators of body burdens of various radioisotopes and elements. (C.O.)

**18122** THE IMMEDIATE AND REMOTE REACTIONS AFTER INTRATISSULAR ADMINISTRATION OF COLLOIDAL RADIOGOLD ($^{198}$Au) IN THE TREATMENT OF MILK-DUCT CARCINOMA. Volkova, M. A.; Pel'man, S. G.; Bergut, F. A.; Kuznetsova, I. P.; Brin, M. L.; Borisov, E. A. (Moscow Scientific-Research Inst. of Oncology). Med. Radiol., 14: No. 2, 8-12(Feb. 1969). (In Russian).

In 170 patients suffering from milk-duct carcinoma who were subjected to conservative treatment and administration of colloidal radiogold ($^{198}$Au) into the tumor, glandular tissue and regional areas, the immediate reactions and remote sequelae (1 to 6 years), were studied. The following criteria were employed: the character of general and local reactions in patients, hematological indices (peripheral blood, bone marrow), and biochemical investigations of the blood (sugar, residual nitrogen, bilirubin, precipitation protein reactions, cholesterol, desintoxication test, clinical blood coagulation tests). The results demonstrated that colloidal radiogold does not cause essential alterations in the function of hematopoietic and parenchymatous organs, both in immediate and remote periods. This made it possible to undertake a radical intervention 12 to 14 days after introduction of the isotope. (auth)

**18123** FACTORS STIMULATING THE OVARIAN FUNCTION IN MAN. A REVIEW. Diczfalusy, Egon; Lamb, Emmet (Karolinska Sjukhuset, Stockholm). pp 97-119 of Pharmacology of Reproduction. Vol. 2. Diczfalusy, E. (ed.). New York, Pergamon Press, Inc., 1968.

From 3rd International Pharmacological Meeting, Sao Paulo, Brazil. See CONF-660726-(Vol.2).

Following a review of present concepts of the regulation of the ovarian function in man, the levels at which the regulatory mechanisms may be influenced for therapeutic purposes are discussed. For the time being, direct stimulation of the central nervous system, hypothalamus, or pituitary is not practical. The use of ionizing radiation, although effective, is no longer justifiable. The same may be said about gonadotropins of animal origin. Human gonadotropins prepared from pituitary glands or urine are highly effective for the induction of ovulation. Synthetic, nonsteroidal compounds, such as clomiphene, which may act via an ovarian-hypothalamic feedback, are also effective. The indications for the use of the various agents and their most frequent side effects are briefly discussed. (auth)

**18124** PHARMACOLOGY OF REPRODUCTION. Proceedings of the Third International Pharmacological Meeting, Sao Paulo, Brazil, July 24-30, 1966. Volume 2. Diczfalusy, E. (ed.). New York, Pergamon Press, Inc., 1968. 132p. $9.00. (CONF-660726-(Vol.2)).

An abstract of one chapter was prepared for inclusion in NSA. Other chapters were concerned with the pharmacological and hormonal controls of the hypothalamus and puberty; chemistry and physiology of factors controlling follicles; control of human testicular function; and pharmacological inhibition of ovarian function. (C.O.)

*For an abstract of the individual chapters see: 18123.*

**18125** RADIATION AND AGING EFFECT ON TASTE STRUCTURE AND FUNCTION. Conger, Alan D.; Wells, Marsha A. (Temple Univ., Philadelphia). Radiat. Res., 37: 34-49(Jan. 1969).

The quantitative effects of radiation and age on taste structure (number of taste buds and number of taste cells per bud) in mice and on taste acuity in therapeutically irradiated humans were studied. After localized head irradiation, both number of buds and number of cells per bud fell rapidly to a minimum about nine days later, with recovery to normal by about 20; the 50% exposure was about 1.5 kR of x rays. Taste-cell lifetime in the bud was brief, only 10½ days. In mice, aging from young adulthood to extreme old age caused about a 30% decrease in number of buds. Humans treated with fractionated therapeutic irradiation (about 6 kR total exposure) to the head and neck suffered a 75 to 99% decrease in their taste acuity to sugar, acid, and quinine. This loss developed during irradiation (about six weeks); preirradiation acuity was recovered within 60 to 100 days after irradiation ended. These experiments suggest that radiation caused direct damage to the nerves, and expressed itself within nine days after exposures of 1 to 2 kR. Against dose, the number of buds was drastically reduced before the number of cells per bud declined very much. A large part of the radioinduced bud loss was not explicable on the basis of simple cell killing and cellular depletion. Similar rapid bud loss was seen after surgical transection of the nerves to the tongue; to be maintained, taste buds require connection to a normally functional nerve. This suggests that radiation impaired the taste-bud maintenance (trophic) function of the nerve. (auth)

**18126** CONTRIBUTION TO THE PROBLEM OF CHEILITIS ACTINICA. Hoefer, W.; Hoenemann, W. Hautarzt, 19: 175-8 (Apr. 1968). (In German).

A case of traumatic actinic cheilitis in an electrowelder is reported and discussed. The sensitivity of skin toward uv irradiation is completely normal in actinic cheilitis, and two forms have been observed. A general uv dermatosis is known as cheilitis actinoallergica and a dermatosis confined to the lower lip is designated as cheilitis hyperheliastica. Low humidity which produces rapid drying of the mucous tissues reduces their resistance to sunlight. In the case reported, increased uv irradiation of the patient in the course of his occupation may have contributed to development of actinic cheilitis. (BBB)

## Radiation Effects on Plants

*Refer also to abstracts 17942 and 17968.*

**18127** (CONF-670503-, pp 111-19) EFFECTS OF IONIZING RADIATION, CLIMATE, AND NUTRITION ON GROWTH AND STRUCTURE OF A LICHEN PARMELIA CONSPERSA (ACH.) ACH. Jones, J. M.; Platt, R. B. (Emory Univ., Atlanta, Ga.).

Colonies of a lichen, Parmelia conspersa, were exposed to $\gamma$ radiation in doses of 17 kR, 35 kR, and 64 kR. Variations of climate and semi-monthly applications of nutrients were made in combination with radiation levels in a $4 \times 2 \times 2 \times 7$ factorial design (radiation, climate, nutrients, month). Radial growth was measured by sequentially superimposing photographs taken at monthly intervals. Analysis of variance with means based on average radial monthly growth accounted for 17% of the total variance and showed that all main effects on growth plus the interaction of climate × radiation were significant ($P < 0.01$). Normal radial growth for six months averaged 1.86 mm, while colonies irradiated with 64 kR averaged 0.92 mm. Growth in the climate chamber was reduced to ⅓ the amount of that under natural conditions. Addition of nutrients increased growth. A gradual increase in monthly growth occurred following radiation exposures, indicating a recovery trend. Additional studies included chlorophyll content, based on optical densities, and isidia development. Climate was significant ($P < 0.01$) in affecting chlorophyll content, while all four factors were significant ($P < 0.05$) for isidia formation. (auth)

**18128** (CONF-670503-, pp 120-6) RADIOSENSITIVITY OF FOREST TREE SPECIES TO ACUTE FAST NEUTRON RADIATION. Witherspoon, J. P. (Oak Ridge National Lab., Tenn.).

For the past two years studies on the response of experimental plant populations to fast neutron radiation have been in progress at ORNL. These studies employed potted forest tree species which were subjected to acute fast neutron radiation and then maintained in greenhouse or growth chamber facilities for observations. Responses in terms of growth, morphological, or mortality criteria were measured for locally important tree species. This information is compared with data on effects of other types of ionizing radiation. In addition, methods of predicting radiosensitivity, such as chromosome volume comparisons, were evaluated for fast neutron radiation. Acute fast neutron doses of 400 to 1500 rads inhibited shoot growth of deciduous species tested by at least 85% under optimal environmental conditions. This may be compared with 6000 to 8500 rads of $\gamma$ radiation necessary to produce the same effect. With mortality as a biological end point, fast neutron irradiations were three to four times more effective than $\gamma$ radiation in the case of woody tree species. (auth)

**18129** (CONF-670503-, pp 185-90) PRIMULA PARRYI: CORRELATION OF MORPHOLOGICAL VARIABILITY WITH BACKGROUND RADIOACTIVITY. Osburn, William S. Jr. (Division of Biology and Medicine (AEC), Washington, D. C. Environmental Sciences Branch).

Excluding areas close-in to nuclear test sites few studies have attempted to determine if radiation from nuclear fallout has produced gross effects within biota. Snowfields in the alpine tundra of the Front Range in Colorado concentrate nuclear fallout to relatively high amounts. Upon melting, nuclear debris released from these snowfields becomes further concentrated within several associated snow-bed plant communities. In 1964, radiation levels in specific sites exceeded 2 microcuries/dec$^2$. As these snow-bed sites contain a 10 to 50 fold concentration of nuclear fallout, organisms within them may be used as sensitive indicators to detect the buildup of damaging levels of fallout long before organisms in other sites may be affected; i.e., unless there is a compensatory difference in organism radiosensitivity, this 10 to 50 fold differential concentration of fallout may well represent a

safety factor index. Primula parryi is often a conspicuous plant of many snow-bed plant communities. During the summer and fall of 1963 a project was conducted to determine whether the morphology of this plant species varied in response to levels of associated ionizing radiation. Despite statistically significant correlation between levels of radioactivity and plant height it was concluded the factors responsible for variations in plant height were length of snow cover and perhaps nutrient supply, rather than a response to radiation. Regardless of possible error in interpretation, data gathered by this study may serve as base level information whereby future levels of ionizing radiation and plant characteristics may be compared. (auth)

**18130** INTERPHASIC CHROMOSOMAL VOLUME IN THE RADIOSENSITIVITY OF TRITICUM. de la Luz Cabrero Abreu, Maria; Villalobos-Pietrini, Rafael (Ciudad Univ., Mexico). Bol. Inst. Estud. Med. Biol. (Mex.)., 25: 83-90(1968). (In Spanish).

The use of the variable interphase chromosomal volume obtained by the difference of nuclear volume minus nucleolar volume, has proved to be highly valuable to ascertain radiosensitivity of a polyploid series of Triticum; it shows that the increase of ploidy is an efficient mechanism of protection against gamma rays. (auth)

**18131** THE OXYGEN AFTEREFFECT IN THE IRRADIATION OF BARLEY SEEDS UNDER LOW-TEMPERATURE CONDITIONS. Gudkov, I. N.; Grodzinskii, D. M. (Inst. of Plant Physiology, Kiev). Radiobiologiya, 8: 883-7(1968). (In Russian).

The admission of oxygen to vacuum-treated barley seeds, irradiated at −196 and −78°, immediately after γ irradiation, intensified the degree of radiation damage as measured by degree of germination. After the seeds were thawed, the oxygen aftereffect was not manifested. Storage of the irradiated seeds under vacuum at these temperatures for several hours led to a weakening of the effect and to its disappearance. From the beginning of sowing of the seeds, the action of oxygen was equally manifested up to temperatures of −60 to −50°, then it was reduced, and did not appear at all at −10 to +20°. (JPRS)

## Radiation Effects on Microorganisms

*Refer also to abstracts 17911, 17953, 17954, 17990, 17991, 18143, 18169, and 18170.*

**18132** (CONF-681006–, pp 77-81) STUDY OF THE BASIC MICROBIOLOGICAL AND BIOCHEMICAL FACTORS INVOLVED IN THE IRRADIATION OF MARINE PRODUCTS. Liston, John (Washington Univ., Seattle. Coll. of Fisheries).

Thirty-four strains of Vibrio parahaemolyticus were tested for radiosensitivity in sea water–peptone water. All strains were reduced from ca $10^7$ org/ml to less than $10^2$ org/ml following irradiation at 50 krads. Fifteen representative strains suspended in fish homogenate plus salt showed less than 10% survival when exposed to 10 krad and even greater sensitivity in fish homogenate without added salt. The strains were approximately twice as resistant to radiation in crabmeat as in fish homogenate but still highly sensitive. Fresh-caught English sole packaged in polyethylene bags were exposed to 25 and 50 krad of radiation and stored in ice. Fillets were then prepared at intervals and stored in polymer pouches at 1°C. No significant reduction in the rate of increase of bacterial counts was noted in any sample. It was concluded that 50 krad was too low a dose to provide assurance of shelf life extension. Lag time and log rate studies were made on Achromobacter-like bacteria believed to be representative of the types causing spoilage of irradiated seafoods. Pure culture studies indicated maximum sensitivity to radiation during the phase of growth acceleration but with some variability from strain to strain. One culture showed clear extension of lag phase. (C.O.)

**18133** (CONF-681006–, pp 83-8) EFFECT OF RADIATION ON THE MICROBIAL FLORA SURVIVING RADIATION PASTEURIZATION OF SEAFOODS. Sinnhuber, R. O.; Lee, J. S. (Oregon State Univ., Corvallis).

The effect of radiation on physiological characteristics of surviving microorganisms and their capabilities to degradate fish meat were investigated. Physiological characteristics of radiation survivors that were investigated were NaCl tolerance, Na benzoate toxicity, and antibiotic sensitivity. The roles of Achromobacter, Pseudomonas, and Flavobacterium species in fish deterioration were also studied. (C.O.)

**18134** (CONF-681006–, pp 227-9) PHYSIOLOGICAL STUDIES ON CLOSTRIDIUM BOTULINUM, TYPE F. Walls, Nancy W. (Georgia Inst. of Tech., Atlanta).

Factors involved in formation of Clostridium botulinum Type F toxin and its appearance in culture supernates were studied using cultures grown at 30 or 10°C after exposure to 0.0, 0.1, or 0.2 Mrad of $^{137}Cs$ γ radiation. Toxin release was essentially logarithmic until maximum titers were reached; maximum toxin titers were higher in irradiated than in nonirradiated cultures. Spores of four strains of Cl. botulinum Type F and of Type E were irradiated at various doses (0.0 to 1.75 Mrad) while suspended in phosphate buffer, nutrient gelatin, or fish homogenates. Survival curves were plotted after postirradiation growth in either fresh pork infusion medium or a medium composed of 5% peptone, 1% yeast extract, 0.1% Na thioglycollate, and 1% agar agar. Data indicated that the nonproteolytic strains of Type F had a radiosensitivity comparable to Type E while proteolytic strains of Type F were more radioresistant. (C.O.)

**18135** (CONF-681006–, pp 231-4) THE EFFECT OF REPEATED TREATMENT WITH GAMMA RAYS ON THE RADIORESISTANCE, VIRULENCE, AND CULTURE CHARACTERISTICS OF CERTAIN PATHOGENIC AND RELATED BACTERIA. Licciardello, J. J.; Nickerson, J. T. R.; Goldblith, S. A. (Massachusetts Inst. of Tech., Cambridge).

Whether repeated γ irradiation of Salmonella cultures increased the radioresistance or virulence, or altered the biochemical or serological characteristics so as to make generic identification difficult was investigated. On the basis of the frequency of radioresistant mutants, it was concluded that the radiation treatment acted more as a selective agent than as a mutagenic agent. Alterations in biochemical characteristics or reactions of the irradiated cultures were minor and were not considered detrimental in identification. The radiation-cycled cultures exhibited some immunological discrepancies in relation to genotype and there were some statistical differences between sensitivity to antibiotics (chloramphenicol, tetracycline, and ampicillin). Radioresistant cultures of S. newport or S. typhimurium were slightly more resistant to penicillin than the radiosensitive cultures. (C.O.)

**18136** (CONF-681006–, pp 235-8) MUTAGENESIS OF ENTEROVIRUSES BY GAMMA RAYS. Cliver, D. O. (Wisconsin Univ., Madison).

Enteroviruses (poliomyelitis, Coxsackie A and B and ECHO) were irradiated at doses of $^{60}Co$ γ rays comparable to those used in low-level irradiation of foods and changes in antigenic specificity, host range, neurotropism, and virulence were sought. No changes that could be attributed to irradiation were found in relation to antigenicity, neurotropsim, and virulence. It was considered possible that irradiation caused acquisition by the Coxsackie virus of the ability to use an adventitious agent in the replicative process. (C.O.)

**18137** NATURE OF THE INFLUENCE OF THE TEMPERATURE OF INCUBATION ON THF SURVIVAL OF IRRADIATED E. COLI B BY γ RAYS. Myasnik, M. N.; Korogodin, V. I. (Inst. of Medical Radiology, Obninsk, USSR). Radiobiologiya, 8: 830-7 (1968). (In Russian).

The survival rate of bacteria E. coli B, possessing the gene $fil^+$, decreases when the temperature of their incubation on the nutrient medium is lowered from 45 to 19°. The effect is intensified after γ irradiation of the cells. The kinetics of the influence of temperature on the survival of irradiated and nonirradiated cells is the same, and in both cases this influence is associated with the formation of filaments. On bacteria E. coli B/r, temperature does not exert such an effect. (JPRS)

**18138** POSTRADIATION CHANGES IN A COMMUNITY OF SOIL MICROORGANISMS. Kashkina, G. B.; Abaturov, Yu. D. (Inst. of Medical Radiology, Obninsk USSR). Radiobiologiya, 8: 908-12(1968). (In Russian).

Gamma irradiation of the soil leads to a disturbance of the natural distribution of organisms in a community of soil microorganisms. Complete post-radiation regeneration of microbiocoenoses is observed when the soil is irradiated at doses up to 10 kR. In the case of larger doses, complete regeneration of the community does not occur, while the number of microorganisms in it is established at a new level. In soils irradiated in the dry state at doses of 250 R and above, 20 days after irradiation an increase in the number of bacteria is noted, significantly exceeding the control. The rate of postradiation regeneration of the community until the establishment of a stationary state is equal to 80 to 100 days. (JPRS)

## Radiosterilization and Radiopreservation

*Refer also to abstracts 18018, and 18132–18134.*

**18139** (CONF-670945) SEVENTH ANNUAL AEC FOOD IRRADIATION CONTRACTORS MEETING, SEPT. 27–28, 1967,

WASHINGTON, D. C. (Division of Isotopes Development (AEC), Washington, D. C. Division of Biology and Medicine (AEC), Washington, D. C.). 243p. CFSTI.

Seven of the sections of this meeting were abstracted separately for inclusion in NSA. Two additional sections covered reports of subcommittees and the report of an invited speaker. (C.O.)

*For abstracts of individual sections see: 18018 and 18140–18145.*

**18140** (CONF-670945–, pp 1-86) MARINE PRODUCTS. (Division of Isotopes Development (AEC), Washington, D. C. Division of Biology and Medicine (AEC), Washington, D. C.).

FOOD IRRADIATION FACILITIES—performance for processing of seafood
MEATS—seafood, radiation processing of, factors affecting efficiency of
—seafood, radiation processing of clam, effects of, on wholesomeness for chickens and dogs
SCHIZOMYCOTA—Clostridium botulinum, radiation effects on growth of, on fish, γ (E.R.B.)

**18141** (CONF-670945–, pp 87-133) FRUITS AND VEGETABLES. (Division of Isotopes Development (AEC), Washington, D. C. Division of Biology and Medicine (AEC), Washington, D. C.).

CALCIUM—loss during storage of γ-irradiated carrots
CALCIUM CHLORIDE—effects on quality and storage of γ-irradiated strawberries
DISEASES, PLANTS—radiation effects on epidemiology of, γ
DOGS—ingestion of γ-irradiated bananas by beagle
FOOD IRRADIATION FACILITIES—performance of Hawaii Development Irradiator, for processing of tropical fruits
FRUITS—strawberries, radiation processing of, effects of, on chickens, dogs, and rats following chronic ingestion, γ
GAMMA RADIATION—effects on pectin content of apples
PACKAGING—effects on storage life of γ-irradiated muchrooms
RADIATION—effects on organoleptic properties, shelf life, and wholesomeness of fruits, factors affecting
RADIATION DOSE—effects on γ-irradiated tropical fruits
VEGETABLES—asparagus, radiation processing of, effects of, on storage quality, γ (E.R.B.)

**18142** (CONF-670945–, pp 134-53) MEAT AND POULTRY. (Division of Isotopes Development (AEC), Washington, D. C. Division of Biology and Medicine (AEC), Washington, D. C.).

FOOD IRRADIATION FACILITIES—design and operation of commercial meat
MEATS—radiation processing of, economic aspects of
—poultry, radiation processing of, bacteriological and economic aspects of
SCHIZOMYCOTA—Salmonella sp., radiation effects on, in processed poultry meat (C.O.)

**18143** (CONF-670945–, pp 154-98) NON-SPECIFIC PRODUCT ORIENTED STUDIES. (Division of Isotopes Development (AEC), Washington, D. C. Division of Biology and Medicine (AEC), Washington, D. C.).

ATOMIC ENERGY, LEGAL ASPECTS—petitions for radiation-processed food
FOOD—radiation processing of, effects of, on stability of lipids
—radiation processing of, economic and packaging aspects of
FOOD IRRADIATION FACILITIES—operation of commercial cesium
MUTATIONS—radioinduced, in enteroviruses γ
RADIATION—effects on heme proteins
SCHIZOMYCOTA—Clostridium botulinum, radiation effects on pathogenic aspects of, in relation to food processing (C.O.)

**18144** (CONF-670945–, pp 199-209) MISCELLANEOUS PRODUCT STUDIES. (Division of Isotopes Development (AEC), Washington, D. C. Division of Biology and Medicine (AEC), Washington, D. C.).

CEREALS—radiation processing of bulk grain, effects of, on insects
VEGETABLES—potatoes, radiation processing of, effects of, on rest period (C.O.)

**18145** (CONF-670945–, pp 237-43) TABLES OF TENTATIVE LEVELS OF IRRADIATION. (Division of Isotopes Development (AEC), Washington, D. C. Division of Biology and Medicine (AEC), Washington, D. C.).

FOOD—radiation processing of, tables of doses for (C.O.)

**18146** (CONF-681006) EIGHTH ANNUAL AEC FOOD IRRADIATION CONTRACTORS' MEETING, OCTOBER 16–17, 1968, WASHINGTON, D. C. (Division of Isotopes Development (AEC), Washington, D. C. Division of Biology and Medicine (AEC), Washington, D. C.). 319p. Dep. GPO $2.50.

Summaries of reports that represent the scope of work carried out during the eighth year of the AEC's Radiation Preservation of Foods Program are presented. Separate abstracts were prepared for 39 papers for inclusion in NSA. The reports are presented to provide the reader with the scope of the work being done in any one specific product area. (C.O.)

*For abstracts of individual papers see: 17989, 17909, 18132–18136, and 18147–18178.*

**18147** (CONF-681006–, pp 3-10) RADIOPASTEURIZATION OF FISHERY PRODUCTS. Ronsivalli, L. J.; King, F. J.; Holston, J. A. (Bureau of Commercial Fisheries, Gloucester, Mass. Technological Lab.).

The effects of irradiation on haddock, cod, ocean perch, softshell clams, pollock, lobster, mackerel, scallops, and blue crab were investigated. Irradiated and nonirradiated fish were subjected to a variety of gas-chromatography analyses. Results concerning the content of free amino acids (FAA), total fatty acids (TFA), and total volatile components (TVC) are presented. The most striking difference between the groups was that a radiation dose. The other research area pursued concerns radiation effects on the growth of Clostridium botulinum Type E and the organoleptic properties of the seafood. (C.O.)

**18148** (CONF-681006–, pp 11-18) FRESH SHRIMP SHIPPING STUDIES AND OPERATIONS OF THE MPDI. Kaylor, John D. (Bureau of Commercial Fisheries, Gloucester, Mass. Technological Lab.).

Raw fresh shrimp were irradiated at 100 and 200 krads and the extension of shelf life as compared with nonirradiated control shrimp subjected to the same commercial methods of irradiation and interstate shipment was determined. Winter and summer shipments were made. Results seemed to indicate that only reasonably fresh, but not exceptionally fresh, white or brown shrimp were necessary to obtain the desired extension of shelf life. The stresses added by shipping four days for 3,000 miles under 90°F temperature conditions were not great enough to be reflected by an experienced taste panel. Also, the present-day commercial methods of shipping in ice were most conducive to the safe transport of fresh raw seafoods whether or not irradiated. (C.O.)

**18149** (CONF-681006–, pp 19-24) RADIATION PASTEURIZATION OF GULF SHELLFISH. Liuzzo, Joseph A. (Louisiana State Univ., Baton Rouge).

The effects of shipping conditions on the quality of cobalt-60 γ irradiated shrimp were investigated. All samples were maintained at ice temperatures from procurement through storage. Organoleptic studies were conducted 3 times a week, total plate counts 2 times a week, and total coliform and fecal coliform determinations weekly. Bacteriological and organoleptic results for 2 shipments of shrimp indicated that levels of 100 and 200 krads extended the keeping qualities of shrimp by 7 to 10 days beyond the control. Levels of 25 and 50 krads were not as effective in eliminating total and fecal coliforms as the two higher doses. Punctures in the double mylar bags used for packaging posed a major problem. (C.O.)

**18150** (CONF-681006–, pp 29-35) APPLICATION OF RADIATION-PASTEURIZATION PROCESSES TO PACIFIC COAST FISHERY PRODUCTS. Miyauchi, David (Bureau of Commercial Fisheries, Seattle, Wash. Technological Lab.).

A series of experiments were completed on five species of fish (Pacific ocean perch, black rockfish, cod, English sole, and Dover sole) that were caught off the coast of Washington and irradiated on-board ship. The objectives were to determine the optimum dose for irradiating fish at sea and the effect of the time interval between catching and irradiating fish on its quality and storage life. Results showed that the optimal radiation dose for Pacific ocean perch, black rockfish, English and Dover sole, and cod was in the range of 50 to 100 krads. The chilled irradiated fish had significantly better storage characteristics than their nonirradiated counterparts. Maximum shelf life values were shorter than the earliest toxin-production time of Clostridium botulinum Type E with the exception of Dover sole fillets that were irradiated at 200 krads and stored at 46°F. (C.O.)

**18151** (CONF-681006–, pp 37-40) PREPARATORY EFFICACY STUDIES FOR THE APPLICATION OF IONIZING RADIATIONS TO THE REFRIGERATION STORAGE OF FRESHWATER PERCH. Graikoski, J. T. (Bureau of Commercial Fisheries, Ann Arbor, Mich.).

Commercially processed yellow perch fillets were irradiated at 0, 100, and 200 krads and then stored at 50, 42, and 36°F. At regular intervals of storage, samples were removed for olfactory

evaluation and microbial plate counts in order to estimate the time for complete rejection of the samples as spoiled. Nonirradiated fish were usually rejected by the 12th day of storage, irrespective of the storage temperature. The storage rejection time of irradiated fish at the 100 and 200 krad level was extended approximately 2- to 3-fold at storage temperatures of 42 and 36°F. Bacterial counts on nonirradiated fish reached rejection level ($10^8$ cells/gm) at approximately the same time as storage temperatures of 50 and 42°F. At 36°F, counts were delayed a few days. The time was extended approximately 2-fold (at various storage temperatures) for bacterial counts to reach rejection on fish irradiated at 100 and 200 krads. At 36°F, there was a greater delay in reaching the rejection level. When fish were aged 3 days prior to irradiation and storage, rejection time did not differ significantly from fish not stored prior to irradiation. (C.O.)

**18152** (CONF-681006–, pp 43-55) GROWTH AND TOXIN PRODUCTION OF CLOSTRIDIUM BOTULINUM TYPE E, NON-PROTEOLYTIC B AND F IN NONIRRADIATED AND IRRADIATED FISHERIES PRODUCTS IN THE TEMPERATURE RANGE OF 38 TO 50°F. Eklund, M. W. (Bureau of Commercial Fisheries, Seattle, Wash. Technological Lab.).

Summaries of studies on toxin production by Clostridium botulinum Type E in nonirradiated and irradiated haddock and petrale, Dover, and English sole fillets; factors in different species of fish responsible for the variability in the low-temperature outgrowth times of Type E spores; outgrowth and toxin production of Cl. botulinum Type E when the inoculum source is from natural sources (marine and freshwater sediments); and lysogeny in different types of Cl. botulinum are presented. With the exception of haddock, the fillets studied supported rapid outgrowth and toxin production of Type E at low temperatures. When the glucose and ribose content of the medium was reduced 75 and 90%, respectively, outgrowth time was increased and toxin titers were reduced. Type E toxin was detected in both the marine and freshwater sediments and for the first time, Type C was detected in freshwater samples from areas north of the Columbia River. Mitomycin C was found to be an excellent agent for activating lysis in actively growing cultures of different types of Cl. botulinum; bacteriophage were found for each of the different types. (C.O.)

**18153** (CONF-681006–, pp 57-61) GROWTH CHARACTERISTICS OF TYPE E CLOSTRIDIUM BOTULINUM IN THE TEMPERATURE RANGE 34 TO 50°F. Segner, W. P.; Schmidt, C. F. (Continential Can Co., Inc., Chicago, Ill. Metal Div. Research and Development).

Irradiated samples of haddock stored at 46 and 50°F tended to show toxin development somewhat earlier than comparable unirradiated samples. When compared on the basis of supposedly equivalent shelf life values, 0.2 Mrad samples definitely showed toxin formation earlier than either 0.1 Mrad-irradiated samples or the unirradiated controls. In general, the results with 0.1 Mrad irradiation appeared quite encouraging for haddock, although the data with 0.2 Mrad irradiation were less favorable. (C.O.)

**18154** (CONF-681006–, pp 63-6) TOXICOGENESIS IN IRRADIATED COD AND FLOUNDER AT LOW STORAGE TEMPERATURES. Graikoski, J. T. (Bureau of Commercial Fisheries, Ann Arbor, Mich.).

Atlantic cod fillets were $\gamma$ irradiated at 100 and 200 krad doses, stored at 10 to 1°C after inoculation at the $10^6$ and $10^4$ Type E spore level within 3 to 6 days, and then checked for toxin. At 10°C, and A $10^2$ spore level, toxin was present within 17, 13, and 10 days at 0, 100, and 200 krad doses. At 70°C, outgrowth and toxin presence under similar experimental conditions were variable. At 3°C, none of the fish fillets tested contained toxin up to 34 days of storage. Additional studies showed that heat-shocked spores (65°C for 15 min) at $10^6$ and $10^7$ spores/ml could be toxic to mice. (C.O.)

**18155** (CONF-681006–, pp 67-71) EFFECT OF GAMMA RAYS ON MARINE FINFISH FILLETS INOCULATED WITH TYPE E CLOSTRIDIUM BOTULINUM. Goldblith, S. A.; Nickerson, J. T. R. (Massachusetts Inst. of Tech., Cambridge).

Samples of haddock were vacuum packed in hermetically sealed metal containers, $\gamma$ irradiated at 100 or 200 krads or not irradiated and held at 50, 45, 42, or 38°F. Toxicity tests on the vacuum-packed irradiated haddock indicated that the product irradiated at 200 krad became toxic at various temperatures prior to the termination of total rejection storage time. Except at 50°F, products vacuum packed and irradiated at 100 krad did not become toxic prior to the total rejection storage time. A summary of the toxicity data is presented in tabular form. It was concluded that no particular type E botulism public health hazard would be involved in processing haddock by vacuum packing and irradiation at 100 krad or at lower dose levels. (C.O.)

**18156** (CONF-681006–, pp 73-6) INOCULATED PACK STUDIES ON LOW-DOSE IRRADIATED MARINE PRODUCTS: SHRIMP. Ward, B. Q. (Miami Univ., Coral Gables, Fla.).

Time lapses (safety margins) were determined between consumer rejection (spoilage) and the development of toxin in shrimp that were inoculated with Clostridium botulinum Type E spores at $10^6$, $10^4$, $10^2$, and 0 levels/g shrimp, irradiated at 200, 100, and 0 krad doses and incubated at 38, 42, 50, and 72°F. In shrimp subjected to 200 krad doses, type E botulism was controlled at all temperatures except 72°F. Toxicity, where it developed, invariably followed and never preceded or parallelled rejection. In general, results with pink and brown shrimp indicated feasibility of radiopasteurization of these types of shrimp; the question of white shrimp is still to be resolved. (C.O.)

**18157** (CONF-681006–, pp 91-7) CHRONIC ANIMAL FEEDING STUDIES ON RADIATION-PASTEURIZED CLAMS. Fegley, Harry C.; Edmunds, Russell S. (Affiliated Medical Enterprizes, Princeton, N. J.).

The wholesomeness of irradiated soft-shell clams (Mya Arenaria) when fed to chickens and dogs was evaluated. The analysis of the chicken study was complicated by the fact that correlations were demonstrable between some parameters and the radiation dose as well as between some parameters and the number of generations on the diet; no conclusions were drawn. With regard to data accumulated from the dog study, it was concluded that statistically significant differences in body weight of the diet groups did occur; no significant difference in weights of animals at autopsy, litter size at whelping, whelping weight, or litter size and the time of weaning were observed; both male and female pups whose parents received normal control diet were significantly smaller than those whose parents received clam control diet; no evidence of birth anomalies or adverse hematological effect was found; no significant inverse correlation between the radiation dose applied to the clams and the blood urea nitrogen level of male dogs receiving them was found; and a significant weight difference between diet groups was observed in liver, kidney, and spleen. (C.O.)

**18158** (CONF-681006–, pp 101-7) HAWAII DEVELOPMENT IRRADIATOR. Dollar, Alexander M. (Hawaii State Dept. of Agriculture).

Objectives of the Hawaii Development Irradiator Program are outlined. Particular emphasis was placed on results of radiation processing of papaya; effective disinfestation and retardation of ripening and senescence were achieved. Preliminary shipping studies confirmed that commercial-scale radiation treatment at 25 and 75 krad was effective in reducing losses during shipment and subsequent storage. (C.O.)

**18159** (CONF-681006–, pp 109-15) DOSIMETRY, TOLERANCE, AND SHELF LIFE EXTENSION RELATED TO DISINFESTATION OF FRUITS AND VEGETABLES BY GAMMA IRRADIATION. Ross, Edward; Moy, James H. (Hawaii Univ., Honolulu).

Progress and results of studies on the effects of $\gamma$ radiation on a number of tropical fruits and vegetables grown in Hawaii are summarized. Included in the summaries are chemical, organoleptic, physical, and physiological data on large-scale shipping tests of Solo papaya; data from ripening experiments designed to define chemical, nutritional, physical, and physiological parameters correlated with radiation processing of Solo papaya, Haden mango, and two radiation dose treatments above established tolerance; limited data on relation of ripening to chemical, nutritional, physical, and physiological parameters of Haden mango, including radiation treatment for shelf life extension. (C.O.)

**18160** (CONF-681006–, pp 117-21) RADIATION PRESERVATION OF TROPICAL FOODSTUFFS. Graham, Horace D.; Luse, R. A.; Cuevas, Jose (Puerto Rico Nuclear Center, Mayaguez).

The feasibility of preservation of mangoes by irradiation and the biochemical characteristics of fruits thus preserved were studied. In all varieties (Sensation, Rubi, Eldon, Keitt, and Kent) studied, shelf life was extended by the radiation treatment. Generally, a dose of 150 krad induced skin and internal blackening, softening, and accelerated ripening in all varieties. Biochemical analyses indicated no important loss of ascorbic acid even at the 150-krad level of treatment. However, a 33% lowering of the content of total carotenoids was noted in the Sensation variety at the 75- to 150-krad levels of treatment. Somewhat similar results were observed for the other varieties. (C.O.)

**18161** (CONF-681006–, pp 123-6) RADIATION TECHNOLOGY IN CONJUNCTION WITH POSTHARVEST PROCEDURES AS A MEANS OF EXTENDING THE SHELF-LIFE OF FRUITS AND VEGETABLES. Maxie, E. C. (California Univ., Davis).

Progress and results of studies on shelf-life extension of fresh mushrooms by $\gamma$ irradiation are presented. Observations made on

white mushrooms, (Agaricus bisporus) exposed to 0 to 200 krad are summarized. A comparison of γ rays and 1 MeV electrons indicated that γ radiation resulted in longer retardation of the cap opening than did electron irradiation at equal doses. It was found that levels of γ radiation up to 40 krad had a rather small effect on fluorescent light-induced greening of potatoes; higher levels (up to 400 krad) did show inhibition of greening. (C.O.)

**18162** (CONF-681006–, pp 127-33) IRRADIATION OF FRUITS AND VEGETABLES. Markakis, P.; Nicholas, R. C. (Michigan State Univ., East Lansing. Dept. of Food Science).

Progress and results of investigations on the feasibility of using γ radiation as a means of reducing postharvest losses of fresh fruits and vegetables are summarized. Rot control in Shasta strawberries without excessive transit injury was observed; Goldsmith variety suffered excessive injury during transit. It was shown that Botrytis cinerea could be controlled better with 100 krad of γ radiation if previously heat-sensitized than 200 krad without heat. Heat radiation treatment of peaches and nectarines was superior to radiation alone for control of Monilinia fructicola. White and brown species of mushrooms responded similarly to γ radiation, each requiring 100 krad for reliable retardation of stem growth and cap opening. Pink and table-ripe tomatoes showed increased shelf life in stationary and simulated transit tests following irradiation of 300 krad. However, in transcontinental rail shipment tests, tomatoes were judged unmarketable. (C.O.)

**18163** (CONF-681006–, pp 135-9) EFFECTS OF LOW-LEVEL IRRADIATION UPON THE PRESERVATION OF FOOD PRODUCTS. Dennison, R. A. (Florida Univ., Gainesville).

Effects of irradiation alone and in combination with pre- and post-irradiation treatments were evaluated in terms of physical and biochemical changes in fresh fruit tissues, organoleptic quality attributes, and decay control. Lemons, peaches, grapefruit, oranges, tomatoes, and mangoes were the fruits or vegetables studied. In general, irradiation affected color changes in lemons and peaches; increased carbon dioxide production from lemons, grapefruit, oranges, peaches, and tomatoes; lessened parameters of texture profile changes of mangoes; induced softening of peaches; delayed ripening of mangoes and peaches; augmented peel injury of citrus fruits during transit; and reduced ascorbic acid content of citrus fruits between 5 and 15%. (C.O.)

**18164** (CONF-681006–, pp 149-53) CHRONIC TOXICITY STUDIES ON LOW-DOSE IRRADIATED BANANAS. Morgareidge, Kenneth (Food and Drug Research Labs., Inc., New York).

Observations and conclusions made after one year of studying γ the effects of chronic feeding of rats and dogs on low-dose irradiated banana powder are summarized. In general, there were no findings in the dogs or rats that suggested an adverse effect due to the treatment of the banana component of the diet with γ radiation. (C.O.)

**18165** (CONF-681006–, pp 155-8) CHRONIC TOXICITY STUDIES ON LOW-DOSE IRRADIATED STRAWBERRIES. Derse, Philip H. (Wisconsin Alumni Research Foundation, Madison).

Chronic toxicity studies on low-dose irradiated strawberries were carried out in chickens, dogs, and rats. After one year two definite effects were noted in rats: decreased rate of weight gain and nephrolithiasis in some females. Both were considered to be due to feeding the high level of strawberries and not related to the feeding of irradiated strawberries. No adverse effects were noted in any parameter in any of the dog studies. Clinical and pathological data on chickens revealed no effects attributable to the feeding of irradiated strawberries. (C.O.)

**18166** (CONF-681006–, pp 161-6) RADIATION PASTEURIZATION OF FRESH MEATS AND POULTRY. Urbain, Walter M. (Michigan State Univ., East Lansing. Dept. of Food Science).

The combination of low-dose irradiation and conventional refrigeration was effective in delaying the onset of microbiological spoilage up to a 21-day postcutting period under laboratory conditions. Satisfactory color was achieved at the end of this period through the combination of anaerobic holding throughout the postcutting and predisplay period following by aerobic holding toward the end of the 21 days and treatment with sodium tripolyphosphate. The need for an antioxidant treatment was not established. Data strongly suggested that at a constant holding temperature of 30°F irradiation was not needed to achieve a 21 day life. Results from a sensory panel indicated no marked adverse effects of the irradiation. (C.O.)

**18167** (CONF-681006–, pp 167-73) COST BENEFIT ANALYSIS OF SELECTED RADIATION PASTEURIZED MEATS. Streever, Donald C. (Yankelovich (Daniel) Inc., New York).

A projected (to 1982) evaluation and estimation of the tangible and intangible benefits likely to accrue as a result of commercialization of radiation pasteurization of meats is presented. Centralization of retail meat cutting and packaging promised substantial economic savings relative to conventional, in-store meat cutting. Labor union contracts, meat merchandising considerations, and meat shelf life limits were considered as obstacles to centralization of meat cutting. The five approaches to extending shelf life, and study findings on key criteria affecting commercial acceptability of each are summarized in tabular form. Net public benefits attributable to centralization of retail meat cutting and packaging, under alternative approaches are also presented. (C.O.)

**18168** (CONF-681006–, pp 175-81) DESIGN, CONSTRUCTION, AND OPERATION OF A COMMERCIAL IRRADIATOR. Silberstein, Morton S. (IRRADCO, Inc., Westwood, N. J.).

Proposals for design, construction, and operation of a commercial irradiation facility for the processing of meats (initially canned hams) and other products are presented. A cobalt-60 source of 400,000 Curies that can be expanded to as much as 5,000,000 Curies with space and shielding is to be used. (C.O.)

**18169** (CONF-681006–, pp 185-8) TREATMENT OF POULTRY WITH IONIZING RADIATIONS TO DESTROY SALMONELLAE. Nickerson, J. T. R.; Licciardello, J. J.; Goldblith, S. A. (Massachusetts Inst. of Tech., Cambridge).

Poultry was contaminated with Salmonella sp. and subjected to radiation doses that provided very low survival levels; the meat was then subjected to abuse treatment by holding at 70°F. In all cases the organisms grew back to high concentrations during holding. Such events also occurred when chicken was inoculated with small numbers of these organisms and subjected to abuse treatment without previous application of ionizing radiation. It was considered probable that the application of radiation treatment at a level of 150,000 rad would reduce any salmonella that might be present to insignificant numbers. (C.O.)

**18170** (CONF-681006–, pp 189-92) MICROBIOLOGICAL ASPECTS OF RADIOPASTEURIZED CHICKEN. Pledger, Richard A. (Hazleton Labs., Inc., Falls Church, Va.).

Methodology was completed for quantification of eight microbial groups or genera on radiation-processed chicken. The methods were used to assess the growth patterns of the eight groups of microorganisms on normal and on presterilized, artificially inoculated, fresh chicken subsequently irradiated at seven different doses and incubated at four different temperatures for different periods of time. Significant observations made were that psychrotrophs appeared always to represent the largest proportion of the microbial types, even after 0.7 Mrad irradiation and incubation at 70°F; Salmonella did not appear to be a problem since hardly any outgrowth occurred with or without radiation treatment; Streptococcus developed high levels on unirradiated chicken at 70°F incubation if they were not in great competition with other cell types; and no Clostridium was detected on normal chicken. (C.O.)

**18171** (CONF-681006–, pp 195-200) COST-BENEFIT STUDIES ON SELECTED AGRICULTURAL AND FISHERY PRODUCTS FOR THE LOW-DOSE FOOD IRRADIATION PROGRAM. Bird, Kermit (Economic Research Service, Washington, D. C.).

The role of irradiation in a group of 19 farm and fishery foods was examined and evaluated. Benefits and costs of the process for each of the foods were estimated. Summary data on production, processing, fresh market handling, and distribution are provided. Products under investigation included fresh market mushrooms, oranges, peaches, strawberries, and tomatoes; fresh or ice packed chicken, frozen turkey rolls and pieces; liquid, frozen, and dried eggs; and packaged rice and flour. Marine products included pond-cultured catfish, clams, crabs, groundfish, halibut, oysters, shrimp, and soles. A detailed summary of the findings on pond-cultured channel catfish is given. (C.O.)

**18172** (CONF-681006–, pp 203-7) FOOD PROGRAM IRRADIATOR SUPPORT. Oltmann, A. (Brookhaven National Lab., Upton, N. Y.).

The operational capability of new and reassigned pool-type and portable research irradiators of AEC ownership or interest is discussed. Experienced design, construction, and operation consultation involving such irradiator elements as source elevators, source handling, conveyors, instrumentation, and source are discussed. The BNL Portable Cesium Development Irradiator is illustrated. (C.O.)

**18173** (CONF-681006–, pp 209-12) FIELD DOSIMETRY STANDARDIZATION. Rizzo, F. Z. (Brookhaven National Lab., Upton, N. Y.).

Cross-calibration dosimetry of portable research and food irradiators was carried out. Both standard Fricke and ferrous cupric sulfate chemical dosimeters were used. Results of the

calibrations indicated good agreement in dose measurement. (C.O.)

**18174** (CONF-681006–, pp 213-17) OPERATION OF THE PORTABLE CESIUM IRRADIATOR. Grant, W. B.; Erlebach, W. E. (Isotopes, Inc., Westwood, N. J.).

The use of a mobile irradiation facility containing 170,000 Ci of $^{137}Cs$ for irradiation of about 20 different products is described. The irradiator was used by different organizations so that they could gain direct experience in evaluating the benefits of radiation processing and in using an irradiation facility. Individual user arrangements involved initial contact, education of the prospective user as to what benefits could reasonably be obtained, and preparation of test protocols for the product of interest. (C.O.)

**18175** (CONF-681006–, pp 221-5) INVESTIGATE ISOLATION AND IDENTIFICATION METHODS FOR DETECTION OF FOOD-BORNE PATHOGENS AND OTHER CHARACTERISTIC END PRODUCTS WITH SPECIAL EMPHASIS ON CLOSTRIDIUM BOTULINUM. Anderson, Arthur W. (Oregon State Univ., Corvallis).

Three different approaches to the identification of Clostridium botulinum Type E in radiation-processed foods were investigated. A comparative cultural method was conducted by growing the organism on liver-veal-agar egg yolk medium (LVA) and on trypticase egg yolk agar medium. Results indicated that LVA egg yolk medium was unreliable with respect to the pearly layer formation. Morphologically distinct culture types were also observed. The second approach used was to identify the enzymes in the metabolic system of the different types of Clostridium using gel electrophoresis. A third approach consisted of developing in vitro procedures for detection and typing of Cl. botulinum toxins in contaminated food products; electrophoretic immunological techniques were used. (C.O.)

**18176** (CONF-681006–, pp 241-4) IRRADIATION STUDIES WITH INSECTS INFESTING BULK-GRAIN AND PACKAGED COMMODITIES. Tilton, E. W.; Brower, J. H.; Cogburn, R. R. (Agricultural Research Service, Savannah, Ga.).

Infested flour and cornmeal in various types of containers were γ irradiated at several dose ranges in a packaged-product irradiator and subsequently monitored for levels of insect infestation. Data indicated that a dose of 30 to 50 krad was sufficient to control eggs and larvae of the red flour beetle, confused flour beetle, saw-toothed grain beetle, almond moth, and Indian meal moth. The almond moth showed a higher degree of sensitivity than was shown by the Indian meal moth and Angoumois grain moth. Tests to determine the combined effects of γ and infrared (IR) radiation on the immature stages of Angoumois grain moth inside wheat kernels were also conducted. Highest mortality occurred in the insects subjected to γ rays followed by IR radiation. (C.O.)

**18177** (CONF-681006–, pp 247-9) EXTRACTION STUDIES OF PACKAGING MATERIALS TO BE USED WITH IRRADIATED FOODS AND PREPARATION OF PETITIONS ON IRRADIATED FOODS. Holsing, G. Carl (Hazleton Labs., Inc., Falls Church, Va.).

Progress and outgrowths of the collection and review of pertinent experimental data generated by AEC and other sources for the preparation of petitions for submission to the FDA for the clearance of irradiated foods and irradiated packaging materials are described. (C.O.)

**18178** (CONF-681006–, pp 253-5) MARINE PRODUCTS TECHNOLOGY AND DEVELOPMENT COMMITTEE. Holston, J. ([Bureau of Commercial Fisheries, Gloucester, Mass. Technological Lab.]).

The evaluation of six summaries of research activities for 1968 that covered 5 major problem areas in the technology of radiation processing (preservation) of certain marine products is described. X-values in relation to cod and haddock fillets, effects of shipping on radiation processed shrimp, radioinduced changes in fish tissue components, and radiation processing at sea were areas covered. It was recommended that all contractors recognize and use the term: minimum justifiable shelf-life extension in place of optimum dose or other synonomous terms. Also, shelf-life estimates of 30 to 40 days that did not take into account the effect of adverse changes in other attributes of quality, i.e., appearance, color, and drip should be dropped. Recommendations in relation to X-values, benefit-cost studies, and combined use of radiation with other preservative methods were given. (C.O.)

**18179** (ORNL-tr-3004) STERILIZATION OF MILK BY IONIZING RADIATION. Veringa, H. A. Translated by Martha Gerrard (Oak Ridge National Lab., Tenn.), from NIZO (Ned. Inst. Zuiverlonderz.) Nieuws, Ser. 12, No. 3, 235-8(1966). 7p. Dep. CFSTI.

The feasibility of preserving certain foods by means of ionizing radiation is becoming increasingly apparent. The results of a literature search on the sterilization of milk by ionizing radiation are presented together with a discussion of the properties and the organoleptic qualities of the sterilized product. The present state of the art indicates that the process is not suitable for milk because of flavor changes. (27 references) (C.O.)

# METALS, CERAMICS, AND OTHER MATERIALS

## Metals and Alloys

### Corrosion and Erosion

*Refer also to abstracts 17389, 17508, and 18225.*

**18180** (ANL-Trans-703, pp 9-44) CORROSION STUDY. (Commissariat a l'Energie Atomique, Fontenay-Aux-Roses (France). Centre d'Etudes Nucleaires). Translated from Section 5 of report CEA-N-969.

Topics covered include: behavior of zirconium alloy in water and superheated vapor, corrosion of magnesium alloys, corrosion of steels and nickel-base alloys, storage of fuel elements, chromium-nickel-iron austenitic alloys, and basic phenomena occurring in corrosion. (M.C.G.)

**18181** (ANL-Trans-718) OBSERVATION OF A TRANSPORT OF CARBON THROUGH LIQUID SODIUM FROM UNSTABILIZED TO STABILIZED AUSTENITIC FINE STEEL. Borgstedt, Hans Ulrich. Translated by Elmar K. Wilip (Argonne National Lab., Ill.), from Corros. Sci., 8: 405-12(June 1968). 12p. Dep. CFSTI.

In static corrosion tests in Na at 600 to 700°C a transfer of C takes place between the unstabilized steel (x 5) 18 Cr-9 Ni and the stabilized steel (x 8) 16 Cr-13 Ni-Mo-V-Nb. The stabilized steel was embrittled in a zone of up to 100 $\mu$m depth after 1000 hr at 700°C. Microprobe analysis shows that embrittlement is accompanied by an enrichment in C. On the surfaces of the specimens a corrosion layer forms which is rich in carbon, but it also contains Na and O. (auth)

**18182** (BNL-50153) HIGH-TEMPERATURE LIQUID-METAL TECHNOLOGY REVIEW. A Bimonthly Technical Progress Review. Volume 6, Number 5. (Brookhaven National Lab., Upton, N. Y.). Oct. 1968. 37p. Dep. CFSTI.

Thirteen brief abstracts review recent reports on reactor development and the technology of high-temperature liquid-metals. The thermophysical and heat transfer properties of alkali metals are discussed as are instrumentation, testing, and monitoring, effects of Na on mechanical elements, development of pumps and steam generators. (P.G.C.)

**18183** (CEA-R-3625) COMPATIBILITY OF VARIOUS MAGNESIUM ALLOYS WITH PRESSURIZED CARBON DIOXIDE AT HIGH TEMPERATURES. Dewanckel, Bernard; David, Rene; Hulin, Christiane; Leclercq, Daniel (Commissariat a l'Energie Atomique, Grenoble (France). Centre d'Etudes Nucleaires). Nov. 1968. 61p. (In French). Dep.

The compatibility of Mg alloys with pressurized $CO_2$ was evaluated by exposing Mg alloy samples containing additions of Zr, Mn, Ce, Zn, Be, and Y at high temperatures. The corrosion kinetics were found comparable with those of conventional Mg-Zr alloy. It appears that the oxidation rate is reduced if traces of water vapor or CO are present. Manifestations of corrosion such as grain size changes and structural changes were studied along with the effects of thermal cycling. The results may be used to compare the behavior of various alloys under varying conditions of long-term use. (J.R.D.)

**18184** (KFK-812) INVESTIGATION OF STRESS CORROSION OF AUSTENITIC STEEL AND NICKEL ALLOYS. Borgstedt, H. U.; Michael, I.; Mueller, St.; Wittig, G. (Kernforschungszentrum, Karlsruhe (West Germany)). June 1968. 42p. (In German). Dep.

The stress crack corrosion of austenitic steels and nickel alloys was studied using 42% $MgCl_2$ solution in water as the corrosive medium. The samples, after washing and drying, were annealed for an hour in high vacuum at 900°C. They were cooled and half the samples were tempered at 600°C for 6 hrs. Both the annealed and tempered samples were exposed to traction at 150°C to determine the value of the rupture limit. The length and potential variations were determined. The results obtained at a temperature of 146 ± 1°C and a tensile stress of 70% of the rupture limit are tabulated. The patterns of typical time-elongation curves are superposed on the patterns of potential curves for specific samples. It was determined that the boiling intensity of the test solution affects the life of the samples. Small temperature variations during the study show no significant effect on the life of the sample. The external appearance of the damaged samples shows differences according to the material and the research conditions. The significance of these results is discussed. (J.S.R.)

**18185** (MSAR-69-7) EFFECT OF HIGH TEMPERATURE SODIUM ON THE MECHANICAL PROPERTIES OF CANDIDATE ALLOYS FOR THE LMFBR PROGRAM. Quarterly Progress Report, July-September 1968. (MSA Research Corp., Evans City, Pa.). Jan. 1969. Contract AT(11-1)-765. 85p. (XAC-720264). Dep. CFSTI.

Data and information are presented on corrosion of austenitic stainless steel by high-temperature sodium, creep rupture of ferritic alloys in high temperature sodium, testing carbon and oxygen meters, and creep rupture of vanadium base alloys in high temperature sodium. (J.R.D.)

**18186** (WAPD-Trans-111) STUDY OF CORROSION AND PROTECTION OF ZIRCONIUM AND ITS ALLOYS. GERMINATION AND GROWTH PHENOMENA DURING THE SURFACE OXIDATION OF ZIRCONIUM. Beranger, G.; Lacombe, P. Translated from pp 181-91 of Metallurgy Symposium, Saclay, June 24-25, 1965. 32p. (CONF-650677-1). Dep. CFSTI.

An abstract of this paper, prepared from the original language, appeared as NSA 21: 18222. (auth)

**18187** (WAPD-Trans-114) STUDY OF CORROSION AND PROTECTION OF ZIRCONIUM AND ITS ALLOYS. Chaudron, G. Translated for Bettis Atomic Power Lab., West Mifflin, Pa., from pp 193-5 of 9th Metallurgy Symposium, Saclay, June 24-25, 1965. [Paris], France, Presses Universitaires, 1966. 10p. (CONF-650677-2). Dep. CFSTI.

The corrosion and oxidation kinetics of zirconium and zirconium alloys are reviewed. The chemical action of $CO_2$ on zirconium is represented by formulas and the experimental results summarized. The oxidation resistance of Cu-Zr is discussed. The Nb-Zr system was studied to define a sheathing alloy having high-temperature mechanical properties and corrosion resistance superior to those of Zircaloy-2. The Cr-Zr alloy was prepared and vacuum treated at 950°C, followed by water tempering. The part Zr deformations play on the structure changes of metals was studied with the aid of an electron microscope. Progress on the study of the attack on zirconium by hydrogen is reported. (J.C.W.)

**18188** EXTRACTION OF NITROGEN, CARBON, AND OXYGEN FROM NIOBIUM BY REACTION WITH ZINC. Meussner, R. A.; Goode, R. J.; Brown, B. F. (Naval Research Lab., Washington, D. C.). J. Less-Common Metals, 17: 411-28(Apr. 1969).

Niobium forms highly stable compounds with nitrogen, carbon, and oxygen. Zinc forms no carbides, its nitrogen compounds are unstable and difficult to prepare, and its oxide is readily reduced. Yet a zinc-rich compound of niobium removes nitrogen, carbon, and oxygen from niobium through the formation of ternary phases of the $\eta$-carbide ($E9_3$) structure. The parabolic rate of growth of the zone depleted of $Nb_2N$ and $Nb_2C$ particles at 850 to 1230°C and the 33 to 34 kcal/mole activation energy of the process indicate that diffusion of nitrogen and carbon in niobium control the extraction process. For oxygen, a surface reaction appears to be rate determining. (auth)

**18189** COMPATIBILITY OF REFRACTORY METALS WITH LIQUID METALS. Hoffman, E. E.; Harrison, R. W. (General Electric Co., Cincinnati). pp 251-87 of Refractory Metal Alloys, Metallurgy and Technology. Machlin, I. (ed.). New York, Plenum Press, 1968.

From Symposium on the Metallurgy and Technology of Refractory Metal Alloys, Washington, D. C. See CONF-680448.

Basic investigations and engineering experiments conducted have demonstrated that refractory metals generally have excellent compatibility with liquid metals. The temperature range of usefulness of the refractory metals begins at temperatures where conventional superalloys still have nominal mechanical strength but do not have the required resistance to corrosion by the liquid metals. The excellent compatibility of refractory metals with liquid metals can be degraded by impurity elements, and the controls required to assure compatibility will be presented. The most significant investigations of refractory metal-alkali metal compatibility have been performed to establish the required technology for the development of Rankine cycle nuclear electric space power systems. This compatibility review is limited to the most significant results obtained in flowing systems where careful control was exercised to control test variables. The discussion includes information from tests of refractory metals in contact with mercury, cesium, potassium, sodium, and lithium. A review is presented describing the compatibility results obtained in a 5000-hour test of a two-loop Nb-1Zr facility in which sodium was circulated in the heater circuit and potassium was boiled and circulated in a two-phase secondary loop which contained turbine simulator test sections of Mo-TZM alloy. (auth)

**18190** REFRACTORY METALS IN SPACE ELECTRIC POWER CONVERSION SYSTEMS. Semmel, J. W. Jr. (General Electric Co., Cincinnati). pp 289-324 of Refractory Metal Alloys. Metallurgy and Technology. Machlin, I. (ed.). New York, Plenum Press, 1968.

From Symposium on the Metallurgy and Technology of Refractory Metal Alloys, Washington, D. C. See CONF-680448.

The status of refractory alloy applications to space electric power conversion systems is reviewed with emphasis on the work related to alkali metal Rankine cycle systems for future power requirements exceeding 100 kW. Niobium and tantalum alloys are considered for alkali metal containment for periods exceeding 10,000 hours at temperatures near 2000°F. In addition, molybdenum alloys are considered for alkali metal vapor turbine wheel and blade applications where weldability is not essential. Results and conclusions from corrosion and erosion tests of refractory alloys in alkali metals are presented. The fabrication of power plant development components from refractory alloys is discussed. (auth)

## *Preparation and Fabrication*

*Refer also to abstracts 17389, 17662, 17714, and 17733.*

**18191** (ANL-7474) PREPARATION OF FIRST MARK IA FUEL ALLOY FOR EBR-II. Miller, W. E.; Bernstein, G. J.; Lenc, J. F.; Paul, R. C. (Argonne National Lab., Ill.). Aug. 1968. Contract W-31-109-eng-38. 19p. Dep. CFSTI.

Fifteen uranium (52.2 ± 1.2 wt % enriched)-fissium Mark IA fuel-alloy ingots were prepared. All the ingots met the composition specifications set up for Mark IA fuel. Fuel pins were injection-cast from these ingots for use in the core of the EBR-II reactor. The feasibility of successfully casting two homogeneous half-ingots in one fuel-alloy preparation run was demonstrated. Spectrophotometric analyses showed 5% higher molybdenum content and 5% lower ruthenium content than x-ray spectrometric analyses of the same Mark IA fuel-alloy ingots. In addition to the 200 kg of Mark IA fuel alloy prepared, 27 kg of uranium-fissium alloy with a higher $^{235}U$ enrichment (69.8 ± 1.2 wt %) was prepared. The latter fuel alloy (designed Special Enriched Fuel Alloy) was made in two preparation runs that were similar to the 15 Mark IA fuel-alloy preparation runs. The Special Enriched Fuel Alloy was prepared to make EBR-II fuel pins which could achieve a desired burnup in a shorter period of time than the Mark IA fuel-alloy pins. Examination of the Special Enriched Fuel Alloy pins after the desired burnup had been achieved would permit valid predictions of the condition of Mark IA fuel-alloy pins after the same burnup. This information was required before the Mark IA fuel-alloy pins were allowed to reach the desired burnup. (J.C.W.)

**18192** (CEA-CONF-1055) OBTAINING REACTIVE TRANSITION METALS THROUGH CARBON REDUCTION. Trouve, J.; Accary, A. (Commissariat a l'Energie Atomique, Saclay (France). Centre d'Etudes Nucleaires). Apr. 1968. 31p. (In French). (CONF-680603-4; DM-1711). Dep.

From 6th International Plansee Seminar on High Temperature Materials, Fundamental and Developments, Reutte, Tirol, Austria.

It is shown that the carbon reduction of oxides of reactive transition metals occurs by a much more complex reaction than the reaction balance equation MO + C → CO + M indicates. The role played by the successive appearance of suboxides, carbides, and the oxycarbides, which increase the reduction temperature as determined from the relevant thermodynamic constants, was studied. The final state of the carbon reduction is examined in detail and the existence of a residual amount of oxygen is shown. This residual oxygen can be significantly lowered by the use of a convenient deoxidant. Optimum conditions for production of high purity reactive metals are outlined. (tr-auth)

**18193** (DUN-AOP-92) FUTURE PLUTONIUM VALUE. Dowis, W. J. (Douglas United Nuclear, Ind., Richland, Wash.). May 24, 1968. 54p. Dep. CFSTI.

A preliminary study of fast breeder reactor fuel needs in the USA was made to predict future Pu availability, need, and value. The assumptions used in the study relative to nuclear power development are stated. Only light-water-moderated reactors of the type now on the market and liquid-metal-cooled fast breeder reactors of the type currently receiving development emphasis were included, with the fuels being limited to Pu and $^{235}U$. It was concluded that as fast breeder reactors achieve market acceptance, plutonium will be more valuable because it is an inherently better fuel than $^{235}U$ and because the cost of $^{235}U$ is expected to increase. (L.C.L.)

**18194** (LIB/Trans-187) TECHNOLOGICAL AND ECONOMICAL IMPROVEMENTS IN THE FABRICATION OF CERAMIC BODIES OF $UO_2$. Gabaglio, M.; Liscia, A. Translated by W. G. Buykx (Australian Atomic Energy Commission Research Establishment, Lucas Heights), from Energ. Nucl. (Milan), 13: 133-8(Mar. 1966). 10p. Dep.

An abstract of this paper, prepared from the original language, appeared as NSA 20: 21300. (L.C.L.)

**18195** (ORNL-4313) FABRICATION HISTORY OF THE FIRST TWO 12-IN.-THICK ASTM A-533 GRADE B, CLASS 1 STEEL PLATES OF THE HEAVY SECTION STEEL TECHNOLOGY PROGRAM, DOCUMENTARY REPORT 1. Childress, C. E. (Oak Ridge National Lab., Tenn.). Feb. 1969. Contract W-7405-eng-26. 121p. Dep. CFSTI.

A-533 grade B plates were received in the as-rolled, stress-relieved, and descaled condition. Heat treatment consisted of normalizing, austenitizing, quenching, tempering, and stress relieving. Tables and curves depicting the available data for each heat-treatment cycle from heat-up through cooling are presented. The first plate was ultrasonically inspected before heat treatment to locate and record any discontinuities for comparison with ultrasonic inspection results after heat treatment. The second plate was ultrasonically inspected after heat treatment only. A complete history of the first two plates from the time they were melted and rolled until they were fully heat treated and cut into sections is given. Except for a summary of austenitizing and quenching data no interpretation of data is included. (auth)

**18196** (RN-TM-564) RESULTS OF NRX-A6 FLAME-SPRAY EVALUATION TEST. Fox, H. A. Jr. (Aerojet-General Corp., Sacramento, Calif. Nuclear Div.). May 10, 1968. Contract SNP-1. 16p. Dep. CFSTI.

The results of the NRX-A6 flame-spray tests are presented. The general objective was to determine the effectiveness of a flame-sprayed aluminum coating used to provide a thermal path between gamma-heated sheathed cables and the reactor pressure vessel. The effects during the maximum-power steady-state period of EP-IIIB, when the heating rates were maximum were determined. Flame sprayed Al effectively reduced cable and conductor temperatures to the temperature of the pressure vessel surface. Temperature of the cables was 50% less than predicted. Flame spraying proved to be a satisfactory method for securing cables and temperature transducers to engine surfaces. (auth)

**18197** EXPLOSIVE WELDING OF A FUEL ELEMENT. Amesz, J.; Holtbecker, H.; Montagnani, M.; Verzeletti, G. (EURATOM, Ispra, Italy). Nucl. Eng. Design, 8: 337-44(Sept.-Oct. 1968).

For welding a plug to a fuel element canning, an explosive wave method has been developed. The materials used were 7% SAP and Zircaloy 2. Satisfactory results were obtained from the point of view of mechanical strength and leak tightness. The method developed gives a weld of unlimited length which does not show detectable variation from the original in the mechanical characteristics of the welded area, employing relatively cheap equipment. In the case of finned tubes, the fins are not damaged by the process. The industrial application of the method is outlined. (auth)

**18198** METHOD FOR PRODUCING RADIATION-SHIELDING LEAD BLOCKS. Kawabata, Rokuro (to Kimura Entetsu Kagaku Kikai Co., Ltd.). Japanese Patent 1968-26481. Nov. 14, 1968. Filed July 21, 1965.

A method is proposed by which voids occurring in lead blocks when cooled can be eliminated using temperature control. After casting a lead block by the ordinary method, holes reaching to a void are cut through from the block surface. The void and the holes are filled with a gas nonreactive with the lead, to prevent the corrosion. Liquid lead is poured into the void via the holes while heated. (NSA of Japan)

**18199** VANADIUM IN JAPAN. 1. Mishima, Yoshitsugu (Tokyo Univ.). Shin Kinzoku Kogyo, 14: 1-6(Jan. 1969). (In Japanese).

The vanadium industry in Japan was reviewed, with emphasis on its nuclear applications. After describing the demand for V, its nuclear uses are discussed. The development work on V and its alloys for fast breeder reactor fuel cladding materials was reviewed. Production of V metal both by fused salt electrolysis and magnesium reduction, preliminary work on preparing and fabricating V alloy sheets, fundamental work on the development of V alloys to be used in flowing sodium above 650°C under irradiation, corrosion studies of V alloys in sodium in Japan are described. (NSA of Japan)

**18200** PLANT FOR CONTINUOUS SINTERING OF PLUTONIUM-CONTAINING FUELS. Kasper, K. Atomwirt., Atomtech., 14: 79-80(Feb. 1969). (In German).

For the processing of uranium oxides and carbides, the ovens used in oxide ceramic industry can be used in most cases without much modification. For the sintering of plutonium-containing fuel elements, oven installations that are suitable for operation with glove boxes are necessary. A semi-automatic installation for the continuous sintering of Pu fuel elements is described. It offers the advantage of the same heat treatment for individual tablets and performed well in operation. (tr-auth)

**18201** A PROCESS OF MANUFACTURING PIPE BENDS OF CAST METALLIC MATERIAL. (to Sulzer Brothers Ltd.). British Patent 1,144,994. Mar. 12, 1969. Priority date Jan. 23, 1967, Switzerland.

A process for producing pipe bends of cast materials such as stainless steel for use in reactor installations is described. The process consists of casting semitoroidal dishes of which the plane of section is at right angles to the rotational axis of the torrus. The dishes are machined and tested. Sections having the desired bend angle are cut from the dish. Sectors with the same bend angle are welded together along longitudinal seams to form pipes. (F.S.)

**18202** FORMATION OF F.C.C., B.C.C., AND $\beta$-TANTALUM FILMS BY EVAPORATION. Marcus, R. B.; Quigley, S. (Bell Telephone Labs., Inc., Murray Hill, N. J.). Thin Solid Films, 2: 467-77(Dec. 1968).

The conditions for formation of evaporated fcc, bcc and $\beta$-tantalum films were studied. It was established that $\beta$-tantalum nucleates on clean (UHV "in situ" cleaved) MgO surfaces; fcc nucleates on surfaces that contain ~1 monolayer of adsorbed impurities. The conversion of fcc to an expanded bcc structure occurs by distortion of a body-centered tetragonal cell; $\Delta\nu \cong 0$ for the transformation. The stability of the fcc phase is in part due to its very thin film form (<100 Å) and the large contribution of surface forces, but a necessary factor is the incorporation of surface impurities at a level near a few atom % in a 50 Å film. The formation of epitaxial $\beta$-tantalum by slow deposition (0.2 Å/sec) onto in situ cleaved MgO is reported. (auth)

**18203** TECHNICAL AND ECONOMICAL PROSPECTS AND FORESEEABLE EVOLUTION OF THE NUCLEAR FUEL CYCLE. Angelini, A. M. Energ. Nucl. (Milan), 16: No. 3, 15-31(Mar. 1969). (In Italian).

A survey is given, with reference to the Western world, of the perspectives and possible evolution of the nuclear fuel cycle, considering all the stages involved. Items examined are availability of expectable reserves of uranium and prospecting activities; future enriched uranium needs and the required increase of current separation capacities; the various aspects of the fuel element fabrication and of their utilization in reactor, and progress achieved or achievable for fuels relevant to the main reactor concepts from both technical and economic aspects; possibilities offered by plutonium recycling in thermal reactors and efforts spent in this direction; perspectives of a high grade utilization of the energy potential of primary sources by means of fast or thermal breeder cycles and the severe technical problems they still present; and, irradiated fuel reprocessing and transport aspects. (tr-auth)

**18204** FUEL CYCLE: REALIZATIONS AND PROGRAMMES OF CNEN. Salvetti, C. Energ. Nucl. (Milan), 16: No. 3, 10-14 (Mar. 1969). (In Italian).

The activities of the Italian Nuclear Energy Committee related to the various stages of the nuclear fuel cycle are reported. The programs include those carried out or proposed to assure to Italy uranium supplies; setting-up of chemical processes to convert yellow cake in uranium metal or oxide; studies on uranium enrichment; development of calculation methods for designing fuel elements and the relevant experimental tests; development of fabrication technologies for various types of fuel elements including those bearing plutonium; and design of prototype plants to reprocess irradiated fuel. (tr-auth)

**18205** STUDY OF THE KINETICS AND EVAPORATION MECHANISMS DURING ELECTRON BEAM MELTING OF Zr–O AND Zr–Si ALLOYS. Gosse, G.; Lehr, P.; Albert, Ph. (CNRS, Vitry-sur-Seine, France). Rev. Int. Hautes Temp. Refract., 5: 299-315(Oct.-Dec. 1968). (In French).

Thermodynamics during electron beam melting of Zr–O and Zr–Si alloys are discussed. The results confirm the possibility of elimination of oxygen in the form of the gaseous monoxide ZrO. The ratio of the partial pressures of the two main species is given as a function of the atomic concentration of oxygen in the melt by the expression $P_{ZrO}/P_{Zr} = (34 \pm 9.6)$ [O] at 2650°K. The vacuum treatment of Zr–Si alloys shows that Si is removed with difficulty from liquid zirconium. Its activity coefficient in dilute solution in zirconium is expressed by $Si(0) = 2.27 \cdot 10^{-3}$ at 2650°K. (tr-auth)

**18206** TECHNOLOGY OF TANTALUM WIRE MANUFACTURE. Stolarz, Stanislaw; Rausz, Aleksander. Rudy Metale Niezelaz., 14: No. 1, 38-44(Jan. 1969). (In Polish).

A powder metallurgical manufacturing process for tantalum products in the form of wire and strip is described. Particular attention is given to the sintering of tantalum powder and the selection of a suitable furnace for resistance sintering of tantalum rods in high vacuum. Satisfactory results were obtained by equipping the vacuum furnace with an attachment, specially constructed for rod sintering. The sintered rods were drawn to wire of 0.5 mm diameter. The described techniques may be applied to industrial scale tantalum wire manufacture. (auth)

## *Properties Evaluations*

*Refer also to abstracts 17686, 17688, and 18182.*

**18207** (CEA-CONF-1139) THERMAL CONDUCTIVITY OF MIXED OXIDES OF URANIUM AND PLUTONIUM. Van Craeynest, Jean Claude; Weilbacher, Jean Claude (Commissariat a l'Energie Atomique, Fontenay-aux-Roses (France). Centre d'Etudes Nucleaires). [1968]. 14p. (In French). (CONF-681116-2). Dep.

From Conference on the Thermal Properties of Solids at High Temperatures, Baden-Baden, Germany.

The thermal conductivity of mixed oxides of U and Pu was measured at 50 to 1000°C by the Angstroem method and at 1000 to 2500°C by the Cowan method. The study of the effect of the oxygen/metal ratio on the thermal diffusivity showed that the effects of stoichiometry is very important up to 1000°C. The variation of the thermal diffusivity was obtained as a function of temperature for O/M ratios of 2.00, 1.98, and 1.93 for temperatures between 50 and 2000°C. The experimental results on stoichiometry were limited to 2000°C because of the stoichiometric modification, but the results were extrapolated to higher temperatures. All the results show that the conductivity of the mixed oxides is increasing at very high temperature. A systematic study of the effect of density on the thermal conductivity of the uranium oxide was made at 50 to 1000°C. The results show that the thermal conductivity depends little on the density at all temperatures for densities between 85 and 100% of theoretical. The results obtained on the effect of the Pu content on the thermal conductivity show that at a given stoichiometry the thermal conductivity is higher for samples with 10% Pu than for samples with 15 or 20% Pu. (J.S.R.)

**18208** (CEA-CONF-1140) SPECIFIC HEAT OF UC, $UO_{2+x}$, AND UN. Affortit, Christian (Commissariat a l'Energie Atomique, Fontenay-aux-Roses (France). Centre d'Etudes Nucleaires). 1968. 16p. (In French). (CONF-681116-1). Dep.

From Conference on the Thermal Properties of Solids at High Temperatures, Baden-Baden, Germany.

The specific heats of UC, $UO_{2.004}$, $UO_{2.009}$, and UN were measured, heating the wire samples from room temperature to the fusion point by passage of an intense direct current. The results obtained are tabulated and shown graphically. They show that the specific heat increases greatly in the vicinity of the fusion temperature. It is probably a general phenomenon, well known in metals, but rarely shown for compounds. (tr-auth)

**18209** (EUR-4085) EFFECTS OF THERMAL ANNEALING AND CYCLING ON LIGHT METAL IMPREGNATED GRAPHITE. Burg, H.; Lanza, F.; Marengo, G. (European Atomic Energy Community, Ispra (Italy). Joint Nuclear Research Center). 1968. 17p. Dep.

The effects of thermal annealing and cycling on dimensional stability of magnesium and Al/Si impregnated graphite have been studied. Dimensional increases up to .3% have been obtained. The results are discussed in terms of annealing of internal stresses due to the different thermal expansion coefficients of the two components of the material. (auth)

**18210** (LA-4062) NUMERICAL SIMULATION OF PROPOSED SURFACE DIFFUSION EXPERIMENTS. Brainard, John P.; Goplen, Bruce (Los Alamos Scientific Lab., N. Mex.). Dec. 1968. Contract W-7405-eng-36. 11p. Dep. CFSTI.

Two possible experiments to measure the surface diffusion of sodium on metal substrates are described. Based on estimated data, numerical calculations were performed to simulate these experiments, and judgments were formed as to their feasibility. (auth)

**18211** (SGAE-M-20/1968) NOBLE GAS DIFFUSION IN LIGHT METALS. Tutschek, E.; Koss, P.; Zika, J. (Oesterreichische Studiengesellschaft fuer Atomenergie G.m.b.H., Seibersdorf. Institut fuer Metallurgie). Oct. 1968. 13p. (In German). Dep.

The diffusion of Xe was investigated qualitatively and quanti-

tatively in Al and Ti. The Xe release rate in linearly increasing temperatures showed a change at 450°C from the grain boundary diffusion mechanism to volume diffusion. The diffusion rate was also studied in undeformed and plastic deformed Al. Plastic deformation cause a significant diffusion increase, which can be attributed to an increase of the vacancy concentration and to the pipe diffusion. In recrystallized samples there is an increase of the diffusion rate. A momentary increase in the Xe release was detected at 882°C in the transformation from $\alpha$ to $\beta$ Ti. (J.S.R.)

**18212** (RPI-3719-6) PRECIPITATION AND DISPERSION HARDENING IN MAGNESIUM BASE ALLOYS. Annual Report. Stoloff, Norman S. (Rensselaer Polytechnic Inst., Troy, N. Y.). Feb. 15, 1969. Contract AT(30-1)-3719. 40p. Dep. CFSTI.

Age hardening response of a Mg–Th–Zr alloy has been studied at 60 to 450°C. Transmission microscopy revealed clustering of thorium atoms at low aging temperatures, supporting a previous report of Guinier-Preston (GP) zone formation. Peak strengthening, which is observed at 325°C, is due to a coherent, ordered $DO_{19}$ type superlattice structure, of probable composition $Mg_3Th$, which forms as plates parallel to the matrix prism planes. These plates later reveal a Laves phase structure of composition $Mg_2Th$. The equilibrium $Mg_4Th$ phase begins to precipitate in two different forms at an early stage, competitively with the $Mg_2Th$ plates. (auth)

**18213** OXIDATION OF PURE Be IN $CO_2$ AT HIGH TEMPERATURES. Nisigaki, Susumu; Nagasaki, Ryukichi. Nippon Kinzoku Gakkaishi, 33: 134-40(Jan. 1969). (In Japanese).

Pure Be was oxidized in flowing $CO_2$ at 550 to 700°C. The observed feature of kinetic discontinuity is explained in terms of oxide morphology. The initial cubic rate results from the formation of an outer thin BeO film and the subsequent growth of the oxide crystallite coherent to the orientation of the underlying metal. The second stage, parabolic, is observed when the oxide looses the crystallographic coherency to the metal and grows as coarse crystals toward the $[10\bar{1}0]$ direction with their (0001) plane parallel to the oxidizing surface. (NSA of Japan)

**18214** A MASS SPECTROMETRIC INVESTIGATION OF THE HIGH-TEMPERATURE DIFFUSION OF URANIUM IN TUNGSTEN AND THE ALLOTROPIC PHASE TRANSITION IN ZIRCONIUM. Schwegler, E. C. Jr.; White, F. A. (Rensselaer Polytechnic Inst., Troy, N. Y.). J. Mass Spectrom. Ion Phys., 1: 191-208 (June 1968).

The diffusion rates of U in W between 1970 and 2730°C were measured using a mass spectrometric technique. In this temperature range the diffusion coefficient (D) of U in W followed the relation: $D = (1.80 \pm 1.05) \times 10^{-2} \exp(-93.0 \pm 6.0 \text{ Kcal mole}^{-1}/RT)$. The mass spectrometer was also used to detect the allotropic phase change in Zr by measuring the change in activation energy for the diffusion of Rb in Zr at 760 to 1030°. To measure the diffusion coefficients, thin ribbons of the solvent metals, each of which contained a low concentration of solute material as an impurity, were used as high-temperature thermal ion sources in a mass spectrometer. The mass spectrometer was utilized to detect the time variation of the solute ion beams from these ribbons for various temperatures. From these data the desired diffusion coefficients were calculated using the Fick's law solution for impurity evaporation from a thin plate. The activation energies were found from plots of the natural logarithm of the diffusion coefficients versus inverse temperature. There is evidence that the results obtained with this method are less subject to error than are classical diffusion measurements due to the fact that small, isolated diffusion samples are used. Also, the solute ion beams can be programmed in magnitude to achieve maximum accuracy and rapidity in diffusion measurements. At present, however, this new method is limited in applicable temperature range. (BBB)

**18215** EFFECT OF TEMPERATURE ON THE BRITTLE FRACTURE OF POLYCRYSTALLINE TUNGSTEN. Valintine, Anne P.; Hull, D. (Univ. of Liverpool). J. Less-Common Metals, 17: 353-61(Apr. 1969).

The effect of temperature on the tensile fracture stress of polycrystalline tungsten of average grain diameter 2d = 0.03 mm has been investigated in the temperature range 77 to 480°K. The onset of the ductile–brittle transition, that is the brittle–semi-brittle transition, occurred at 350°K. Below this transition the fracture stress increased with decreasing temperature. Above 473°K grain-boundary cracking was observed on the specimen surface. The effect of spark-induced microcracks on the fracture stress was studied as a function of microcrack length at 77°K and testing temperature between 77 and 480°K. The fracture stresses at 77°K followed the Griffith relation to give a value to the surface energy that was close to the theoretical value for the true surface energy. The effect of blunt grain-boundary cracks on the fracture of tungsten was shown by prestraining the material to 2 and 4% strain at 473°K prior to testing at lower temperatures. The temperature dependence of this fracture stress was less than for sharp spark-induced cracks. (auth)

**18216** THE EFFECTS OF STRAIN RATE AND PRESSURIZATION ON THE DUCTILE-BRITTLE TRANSITION TEMPERATURE OF POLYCRYSTALLINE SINTERED TUNGSTEN. Chilton, A. C.; Wronski, A. S. (Univ. of Bradford, Eng.). J. Less-Common Metals, 17: 447-50(Apr. 1969).

Tensile test pieces were ground from $\frac{1}{4}$ in. diameter sintered W rod. Thirty specimens were used to investigate the effects of pressurization and 50 samples were used to study the effect of strain rate. All specimens were recrystallized to a grain diameter of ~50 $\mu$ by heat treatments at 1 hr at ~1750°C in vacua of $10^{-6}$ torr. Then the specimens were electropolished. Metallographic examination revealed non-propagating cracks, away from the fracture surfaces, only in ductile specimens. In this polycrystalline sintered tungsten the transition from ductile to brittle behavior appears to occur at a constant stress of $\sigma_f^* \pm 4$ kG mm$^{-2}$ for strain rates from $10^{-5}$ to $10^{-2}$ sec$^{-1}$ as the transition temperature is raised from ~377 to ~465°K. (J.C.W.)

**18217** RELATION BETWEEN ULTIMATE TENSILE STRENGTH AND HARDNESS OF NIOBIUM ALLOYS AT ROOM AND ELEVATED TEMPERATURES. Zakharov, A. M.; Savitskii, E. M. Tr. Metrol. Inst. SSSR, 91: No. 151, 5-9(1967). (In Russian).

A study was made of the relation between ultimate tensile strength (UTS) and hardness for binary (Nb–W, Nb–Mo), ternary (Nb–W–Zr, Nb–Mo–Zr, and Nb–W–Mo), and quaternary (Nb–W–Mo–Zr) alloys at room temperature and at 1300, 1400, and 1500°C. Test specimens were extended at 5 mm min$^{-1}$ and hardness (HV) measured with a 10 kG load. A special machine enabled the determination of high temperature hardness to be made either in vacuum or in an inert gas atmosphere up to 1650°C. The hot hardness was measured with a sapphire cone under a 5 kG load. Tests were made on Nb and Nb alloyed with W, Mo, and Zr in the annealed condition. These alloys either have a single phase structure or contain small quantities of a second phase. A linear relationship was established between UTS and hardness in both temperature regions, UTS = 0.34 HV (room temperature) and UTS = 0.36 $H_k$ (1300 to 1500°C) where $H_k$ is the hot hardness. (Referativnyi Zn.)

**18218** DESIGN DATA DEVELOPED FOR THREE NEW SUPERALLOYS. Hockin, John. Precis. Metal, 26: 67-70(Jan. 1968).

Three new alloys were introduced for use in turbine components. MAR-M alloy 246 has the highest rupture strength at 1200 to 2000°F of any available alloy. It is used for applications requiring high strength, creep resistance oxidation resistance at elevated temperatures. Composition is 0.15% C, 9.0% Cr, 10.0% Co, 10.0% W, 2.5% Mo, 1.5% Ta, 1.5% Ti, 5.5% Al, 0.015% B, 0.05% Zr, balance Ni. MAR-M alloy 421 provides increased sulfidation resistance with high strength, ductility and stability. Creep rupture strength is good and the alloy composition is balanced to eliminate the possibility of forming embrittling phases. Composition is 15% C, 15.5% Cr, 9.5% Co, 3.8% W, 2.0% Mo, 1.8% Ti, 4.2% Al, 0.015% B, 0.05% Zr, 2.0% Nb, balance Ni. MAR-M alloy 509 is a Co-base alloy for elevated temperature service in advanced aircraft gas turbines. It combines high creep strength with resistance to thermal shock, crack propagation and oxidation. Composition is 0.60% C, 23.5% Cr, 7.0% W, 3.5% Ta, 0.2% Ti, 0.5% Zr, 10% Ni, balance Co. (F.S.)

**18219** TAMING TITANIUM. Stacher, George (Lockheed-Georgia Co., Marietta, Ga.). Lockheed Ga. Quart., 6: No. 1, 26-32(Feb. 1969).

The establishment of extrusion parameters, heat treatment processes, straightening methods, machining techniques, and the requisite mechanical testing procedures for titanium are reported for its application on supersonic, high altitude aircraft. The economic factors are reviewed. Alloys studied included Ti–6Al–4V and Ti–6Al–6V–2Sn. (J.C.W.)

**18220** SURFACE FREE ENERGY OF SOLID MOLYBDENUM. Allen, B. C. (Battelle Memorial Inst., Columbus, Ohio). J. Less-Common Metals, 17: 403-10(Apr. 1969).

The average surface free energy of solid molybdenum has been measured using the Udin zero creep method at 2500°C under 1 atm of tantalum-gettered argon. Strains were measured at the creep temperature. Surface energy values agree with previous work in which strains were measured at room temperature. The most probable value is 1900 ergs/cm$^2$ which is about 15% lower than the liquid surface tension. Residual impurity adsorption is believed to be the cause of the low value. Volume diffusion coefficients determined from the Herring–Nabarro creep rate equation agree with the published radioactive tracer results within a factor of 2. (auth)

**18221** REFRACTORY METAL ALLOYS. METALLURGY AND TECHNOLOGY. Proceedings of a Symposium held in Washington, D. C., April 25–26, 1968. Machlin, I.; Begley, R. T.; Weisert, E. D. (eds.). A Publication of The Metallurgical Society of AIME. New York, Plenum Press, 1968. 499p. $22.50. CONF-680448.

A separate abstract was prepared for each of the twelve papers presented at the conference. (J.R.D.)

*For abstracts of individual papers see: 18189, 18190, 18222–18229, 18246, and 18247.*

**18222** BASIC STRENGTHENING MECHANISMS IN REFRACTORY METALS. Wilcox, B. A. (Battelle Memorial Inst., Columbus, Ohio). pp 1-39 of Refractory Metal Alloys. Metallurgy and Technology. Machlin, I. (ed.). New York, Plenum Press, 1968.

From Symposium on the Metallurgy and Technology of Refractory Metal Alloys, Washington, D. C. See CONF-680448.

Various mechanisms of strengthening refractory metals and alloys are discussed. Special emphasis is placed on the microstructural features which can be varied to produce strengthening, and relevant illustrations are given. The general areas reviewed include: strengthening by second phase particles, solid solution strengthening, strain hardening and grain size refinement, retaining worked structures at high temperatures, dynamic strengthening, and fiber reinforcement. (auth)

**18223** HIGH TEMPERATURE CREEP AND FRACTURE BEHAVIOR OF THE REFRACTORY METALS. Begley, R. T.; Harrod, D. L.; Gold, R. E. pp 41-83 of Refractory Metal Alloys. Metallurgy and Technology. Machlin, I. (ed.). New York, Plenum Press, 1968.

From Symposium on the Metallurgy and Technology of Refractory Metal Alloys, Washington, D. C. See CONF-680448.

The creep properties of the pure, polycrystalline refractory metals are reviewed and summarized. The creep behavior of all the pure metals is correlated in terms of their diffusivities and elastic moduli following the Sherby-type analysis. Experimental values of the activation energy and stress dependence of creep are also summarized for the pure metals, and the structural features of deformation and fracture are described. The general effects of alloying are delineated in terms of solid solution, dispersed phase, and strain hardening contributions to high temperature creep strength. (auth)

**18224** EFFECT OF THERMAL–MECHANICAL TREATMENTS ON THE STRUCTURE AND PROPERTIES OF REFRACTORY METALS. Perkins, Roger A. (Lockheed Missiles and Space Co., Palo Alto, Calif.). pp 85-120 of Refractory Metal Alloys. Metallurgy and Technology. Machlin, I. (ed.). New York, Plenum Press, 1968.

From Symposium on the Metallurgy and Technology of Refractory Metal Alloys, Washington, D. C. See CONF-680448.

The control of properties by thermal-mechanical treatments is based on mechanical deformation and annealing according to a schedule that will produce a unique and stable combination of grain structure, dislocation substructure, texture, and dispersion of precipitated phases. The formation and stabilization of deformation substructures in Nb, Ta, Mo, W, and their alloys is reviewed. The effect of thermal-mechanical treatments on grain structure and texture also is considered. Examples are given to illustrate how the ductile-to-brittle transition behavior, low temperature strength and ductility, high temperature strength, creep resistance, and formability are affected by the structural changes that can be produced. Results obtained indicate major advances in refractory metal technology by the application of thermal-mechanical treatments. The challenge relates the basic concepts and understanding of the control of structure and properties to the metal working processes required to produce metals in appropriate shapes or forms. (auth)

**18225** INTERACTIONS IN COATED REFRACTORY METAL SYSTEMS. Metcalfe, Arthur G.; Stetson, Alvin R. pp 121-63 of Refractory Metal Alloys. Metallurgy and Technology. Machlin, I. (ed.). New York, Plenum Press, 1968.

From Symposium on the Metallurgy and Technology of Refractory Metal Alloys, Washington, D. C. See CONF-680448.

Typical protective coating systems for refractory metals consist of a primary oxide barrier, a secondary barrier or reservoir, and a ternary barrier formed by surface alloying the substrate. Interaction between these various barrier layers and the substrate and atmosphere are examined. Discussions are included on expansion mismatch, interstitial sink effects, effect of coatings on mechanical properties, diffusion processes that control coating life, and metallic claddings. Methods of alleviating complex interaction effects are discussed and illustrated by aspects of low temperature oxidation processes of refractory silicide coatings, crack arresting effects of porosity in coatings, coatings containing a molten phase, and low pressure effects. A review of future approaches is presented. (auth)

**18226** THE LESS COMMON REFRACTORY METALS (RHENIUM, TECHNETIUM, HAFNIUM, NOBLE METALS). Maltz, Joseph (National Aeronautics and Space Administration, Washington, D. C.). pp 451-488 of Refractory Metal Alloys. Metallurgy and Technology. Machlin, I. (ed.). New York, Plenum Press, 1968.

From Symposium on the Metallurgy and Technology of Refractory Metal Alloys, Washington, D. C. See CONF-680448.

The physical metallurgy of rhenium and of technetium, an artificial element which has only recently become available in sufficient amount for metallurgical studies to be possible, are surveyed. New data on phase equilibria, mechanical and physical properties and availability are included. Special attention is also given to the roles of hafnium-tantalum alloys and of iridium as oxidation-resistant coatings suitable for special situations. Insofar as the potential usage of the less common refractory metals in applications which depend upon their high melting point is concerned, high cost and low availability preclude any radical changes in the near future. (auth)

**18227** ADVANCED PROCESSING TECHNOLOGY AND HIGH TEMPERATURE MECHANICAL PROPERTIES OF TUNGSTEN BASE ALLOYS. A REVIEW. Sell, H. G. (Westinghouse Lamp Div., Bloomfield, N. J.). pp 395-450 of Refractory Metal Alloys. Metallurgy and Technology. Machlin, I. (ed.). New York, Plenum Press, 1968.

From Symposium on the Metallurgy and Technology of Refractory Metal Alloys, Washington, D. C. See CONF-680448.

Advances made in the manufacturing of tungsten base alloys by powder metallurgy, fusion, and chemical vapor deposition techniques are reviewed. The mechanical properties of many alloys are discussed in terms of the effect of alloying on the ductile-brittle transition temperature and on the high temperature tensile and creep strength. (auth)

**18228** CONSIDERATIONS IN THE DEVELOPMENT OF TANTALUM BASE ALLOYS. Buckman, R. W. Jr.; Goodspeed, R. C. (Westinghouse Astronuclear Lab., Pittsburgh). pp 373-94 of Refractory Metal Alloys. Metallurgy and Technology. Machlin, I. (ed.). New York, Plenum Press, 1968.

From Symposium on the Metallurgy and Technology of Refractory Metal Alloys, Washington, D. C. See CONF-680448.

The alloying behavior is reviewed of tantalum with discussion being restricted primarily to the effects of the alloying additions tungsten, hafnium, rhenium, and carbon. The effect of each of these additions on tensile strength, fabricability, and creep behavior is discussed. The status of current commercially available tantalum base alloys is presented and the potential strength limit of alloy compositions which retain room temperature ductility is proposed. (auth)

**18229** RECENT ADVANCES IN NIOBIUM ALLOYS. Frank, R. G. (General Electric Co., Cincinnati). pp 325-72 of Refractory Metal Alloys. Metallurgy and Technology. Machlin, I. (ed.). New York, Plenum Press, 1968.

From Symposium on the Metallurgy and Technology of Refractory Metal Alloys, Washington, D. C. See CONF-680448.

The status of niobium alloys is reviewed with respect to major applications, production, cost and selected properties. Alloys with low to moderate strength and good ductility and that are readily fabricable and weldable are commercially available. These alloys were the first of the niobium base alloys to receive serious consideration for use in components on actual flight systems. Emphasis in the development of new niobium alloys over the past several years has been directed toward the achievement of greater creep strength in the 2000 to 2400°F temperature range and more recently, improved oxidation resistance in combination with varying levels of strength and ductility. (auth)

**18230** DIFFUSION OF CARBON, NITROGEN, AND OXYGEN IN BETA THORIUM. Peterson, D. T.; Carnahan, T. (Ames Lab., Iowa). Trans. Met. Soc. AIME, 245: 213-15(Feb. 1969).

The diffusion coefficients of carbon, nitrogen, and oxygen were determined in $\beta$ thorium over the temperature range 1440 to 1715°C. The diffusion coefficients are given by: $D = 0.022 \exp(-27{,}000/RT)$ for carbon, $D = 0.0032 \exp(-17{,}000/RT)$ for nitrogen, and $D = 0.0013 \exp(-11{,}000/RT)$ for oxygen. Carbon was found to increase the hardness of thorium nearly linearly with concentration over the range 100 to 1000 ppM carbon. (auth)

**18231** EFFECTS OF SHORT-CIRCUITING PATHS ON DIFFUSION COEFFICIENT MEASUREMENTS. Lundy, T. S.; Pawel, R. E. (Oak Ridge National Lab., Tenn.). Trans. Met. Soc. AIME, 245: 283-6(Feb. 1969).

Effects of short-circuiting paths on observed diffusion behav-

ior in real crystalline systems are considered. It is concluded that experimentally measured diffusion coefficients may vary widely from values associated with true lattice diffusion to those appropriate for short-circuiting paths alone depending upon the conditions of the experiment and the sensitivity and completeness of the data. Monocrystalline and polycrystalline tungsten were used. Gaussian plots for the diffusion of $^{95}Nb$ in monocrystalline and polycrystalline tungsten are presented. (J.C.W.)

**18232** CHEMICAL COMPATIBILITY OF NICKEL AND MOLYBDENUM FIBERS WITH BERYLLIUM. Watts, C. R. (Aerospace Corp., El Segundo, Calif.). Trans. Met. Soc. AIME, 245: 329-33(Feb. 1969).

The feasibility of producing composites containing nickel or molybdenum fibers in a beryllium matrix was investigated. The composites studied were fabricated by powder metallurgical techniques. The 1-mil-dia nickel fibers reacted completely below 900°C, converting the fibers from nickel to $Ni_5Be_{21}$. As the hot-pressing temperature was raised above 1100°C, the nickel diffused outward from the beryllide fibers. The solid solubility of nickel in beryllium was about 20 wt % at the 1100°C pressing temperature at the zone-fiber interface. The 1.5-mil-dia molybdenum fibers showed no evidence of reaction and little evidence of diffusion after pressing at 900°C. Between 1000 and 1050°C pressing conditions, the fibers began to react, producing layers of $MoBe_2$ and $MoBe_{12}$, respectively, surrounding the molybdenum core. The structure remained the same at 1100°C with no evidence of solid solubility at the molybdenum in the beryllium or vice versa. (auth)

**18233** SUPERPLASTICITY IN TUNGSTEN–RHENIUM ALLOYS. Garfinkle, M.; Witzke, W. R.; Klopp, W. D. (Lewis Research Center, Cleveland). Trans. Met. Soc. AIME, 245: 303-8(Feb. 1969).

The tensile properties of binary W–Re alloys containing up to 33 at. % Re were determined at temperatures from 78 to 3630°F. Elongations as high as 260% were observed in electron-beam-melted tungsten containing 23 at. % Re when tensile-tested at 3630°F after a 1-hr anneal at 3090°F. All alloys tested under these conditions with rhenium contents between 20 and 28 at. % exhibited elongations of at least 200%. These alloys also showed enhanced grain growth rates. The values of strain-rate sensitivity ranged between 0.2 and 0.3 for the alloys exhibiting high elongations. However, for swaged alloys tested just above the recrystallization temperature, strain-rate sensitivities as high as 0.8 were observed. The high-temperature strengths of the high-rhenium-content alloys were also less than those of alloys with intermediate rhenium contents. (auth)

**18234** INTERMEDIATE COMPOUNDS $Ni_8Nb$(Cb) IN NICKEL-RICH NICKEL–NIOBIUM (COLUMBIUM) ALLOYS. Quist, W. E.; van der Wekken, C. J.; Taggart, R.; Polonis, D. H. (Univ. of Washington, Seattle). Trans. Met. Soc. AIME, 245: 345-9(Feb. 1969).

An intermediate compound that has been identified as $Ni_8Nb$ is observed to form as a decomposition product from supersaturated Ni–Nb solid solutions during aging at temperatures between approximately 300 and 500°C. On the basis of data from electron microscopy and selected-area diffraction, the structure of this compound has been determined as fct with $a = b \simeq 3a_0$ and $c \simeq a_0$ where $a_0$ is the lattice parameter of the parent solid solution. The compound consists of close-packed layers with triangular ordering, where the niobium atoms are separated by two nickel atoms along close-packed directions. A nine layer stacking sequence is required to describe the proposed structure. (auth)

**18235** INFLUENCE OF RARE EARTHS METALS IN THE NIOBIUM PURIFICATION. Trombe, Felix; Male, Germain (CNRS, Bellevue, France). Rev. Int. Hautes Temp. Refract., 5: 295-8(Oct.-Dec. 1968). (In French).

The rare earths elements added to niobium have a deoxidizing or desulfiding action. Carbon can be separated from niobium only in presence of oxygen. It is also shown that an excess of rare earths in the solid phase may be detrimental to the mechanical properties of niobium at high temperatures. A study has been made of the behavior of niobium with small amounts of lanthanum (0.1 to 5%). Lanthanum remains in niobium in small quantities (0.1 to 0.85%), when prepared in an electron beam furnace. All the prepared compounds show a notable decrease of hardness in comparison with the hardness of niobium without La. (tr-auth)

**18236** VISCOSITIES OF CADMIUM AND INDIUM. Crawley, A. F.; Thresh, H. R. (Dept. of Energy, Mines, and Resources, Ottawa). Trans. Met. Soc. AIME, 245: 424-5(Feb. 1969).

Viscosities were measured using an absolute technique applied to an oscillating closed right cylinder of liquid metal. Densities were determined by a pycnometric technique for the liquid cadmium and indium. The viscosity of cadmium was measured to 451.8°C and of indium to 346.5°C. Andrade's equation was applied to describe the temperature dependence of viscosity. (J.C.W.)

**18237** FORGING MATERIALS AND PRACTICES. Sabroff, A. M.; Boulger, F. W.; Henning, H. J. New York, Reinhold Book Corporation, 1968. 373p. $16.50.

The forging information presented includes data from the literature, industrial source, and special laboratory-scale experimental programs. Empirical relationships developed for forging processes intended to serve as guides for establishing design limits and shop practices are discussed. Forged shapes are discussed. The influence of material properties on forging behavior is included for titanium, beryllium, nickel-base alloys, precipitation-hardening stainless steels, and the refractory metals. New melting and alloying techniques and the new metal-fabricating processes such as impacter forging, explosive forming, and high-velocity forging are discussed. (J.C.W.)

## *Structure and Phase Studies*

*Refer also to abstract 18279.*

**18238** (LA–3870) CONSTITUTION OF PLUTONIUM ALLOYS. Ellinger, F. H.; Miner, W. N.; O'Boyle, D. R.; Schonfeld, F. W. (Los Alamos Scientific Lab., N. Mex.). Jan. 1968. Contract W-7405-eng-36. 185p. Dep. CFSTI.

The phase relationships and crystal structures of the intermediate phases in 75 binary and 17 ternary, or higher, alloy systems of plutonium with other elements are presented. (J.C.W.)

**18239** (ORO–3262-10) AN INVESTIGATION OF THE COMPONENTS OF THE FLOW STRESS IN TITANIUM AND ZIRCONIUM. Progress Report. [Reed-Hill, R. E.; Ramachandran, V.; Santhanam, A. T.] (Florida Univ., Gainesville. Engineering and Industrial Experiment Station). Feb. 21, 1969. Contract AT(40-1)-3262. 29p. Dep. CFSTI.

Progress is reported in research on flow stresses of Zr and Ti, effects of strain rate changes on the shape of stress strain curve in metals, strain anisotropy in Ti, theory of relaxation in metals, twinning during deformation of Zr at 77°K, processes for improving Zr ductility, and processes for increasing damping capacity in Zr. Results of investigations are reported on the error of using yield stress as a measure of hexagonal metal load-carrying capacity, active slip modes and twinning in single crystal and polycrystalline Zr, deformation in Zr at 4°K, and polycrystalline deformation. (J.R.D.)

**18240** STUDY OF THE $\gamma \rightarrow \beta$ TRANSFORMATION IN U–1 AT. % Cr. Kittl, J. E.; Rodriguez, C.; Marcone, N. J.; Vassallo, D. (Comision Nacional de Energia Atomica, Buenos Aires). Metalurgia (Sao Paulo), 23: 429-39(June 1967). (In Spanish).

A brief review is given of certain concepts in non-solid state transformations with special emphasis on massive transformations and the results predicted in the $\gamma \rightarrow \beta$ transformation in uranium. Data from metallographic observation of uranium alloys with 1 at. % Cr are presented. These alloys are transformed with a known rate. The equipment constructed for the observations is described. The results obtained on the variation of the surface transformation temperature up to transformation indicate that up to 1500°C/sec cooling there is massive transformation. The existence of an internal fine structure and $\beta$ subgrain is shown and their probable origin is discussed. (tr-auth)

**18241** DECOMPOSITION BY HYDROGEN OF A ZIRCONIUM–LEAD INTERMETALLIC COMPOUND IN A Mg–Pb–Zr ALLOY. Pegoud, Joseph; Guillaumin, Jean; Millet, Pierre (SICN, Isere, France. CEN de Saclay, Gif-sur-Yvette, France). Compt. Rend., Ser. C, 268: 312-14(Jan. 27, 1969). (In French).

Evidence is presented by means of electron microscopy and electron microdiffraction of a reaction that occurs in the solid state between hydrogen and the intermetallic compound $Zr_5Pb_3$ precipitated in a Mg–Pb–Zr alloy. The hydrogen displaces the lead, and zirconium hydride is formed. (tr-auth)

**18242** OCCURRENCE OF CsCl-TYPE PHASES AND OF RELATED DISTORTED STRUCTURES IN ALLOYS OF TRANSITION METALS. Dwight, A. E. (Argonne National Lab., Ill.); Beck, Paul A. Trans. Met. Soc. AIME, 245: 389-90(Feb. 1969).

Known CsCl-type phases in transition metal alloys are shown to be formed preferentially at an electron concentration of approximately 6; a tetragonally distorted version of the CsCl structure is stable at $\sim e/a = 6.5$. The relationship of the distortion to electron concentration is verified by experimental data for the quasibinary systems Ti(Re,Os), Ti(Re,Ir) and Ti(Re,Pt) and the ternary system Ti–Ru–Rh. (auth)

**18243** OMEGA TRANSFORMATION IN ZIRCONIUM ALLOYS. Chaturvedi, M.; Tangri, K. (Univ. of Manitoba, Winnipeg). Trans. Met. Soc. AIME, 245: 259-66(Feb. 1969).

On water-quenching from within the ($\alpha + \beta$) phase region Zr–2.5 Nb and Zr–2.5 Nb–0.5 Cu alloys can undergo $\omega$ transformation. This transformation has been attributed to the enrichment of $\beta$ Zr phase, at the solution-treatment temperature, by the solute atoms. The $\beta-\omega$ transformation is accompanied by a hardening of the alloys and in the optimum condition $\omega$-bearing specimens of the ternary alloy are about 14% harder than those bearing only $\alpha'$ phase. On aging $\omega$ reverts thermally to more stable phases, which results in a considerable softening of the specimens, as follows: $\omega_{quenched} \rightarrow \omega_{aged} + \beta$ Zr (enriched) and $\omega_{aged} \rightarrow \alpha + \beta$ Nb. (auth)

**18244** CLOSE-PACKED ORDERED $AB_3$ STRUCTURES IN BINARY TRANSITION METAL ALLOYS. Sinha, Ashok K. (Univ. of Illinois, Urbana). Trans. Met. Soc. AIME, 245: 237-40(Feb. 1969).

An investigation into the occurrence of ordered $AB_3$ structures, revealed new phases— $CrRh_3$ ($AuCu_3$ type), $CrCo_3$ ($MgCd_3$ type), $HfCo_4$ ($Th_6Mn_{23}$ type), and $WPt_3$ ($MoPt_2$ type). The composition of the $TiPt_{3-x}$ phase ($TiNi_3$ type) is close to $Ti_{23}Pt_{77}$. The alloy chemistry of transition metal $AB_3$ structures is reviewed in the light of electron concentration correlations of hexagonality recently obtained for quasi-binary alloys. The relative volume contraction in the $AB_3$ structures increases with increasing difference in volume of the components. (auth)

**18245** EVIDENCE FOR PLASTIC DEFORMATION IN $HoZn_2$. Michel, D. J.; Ryba, E. (Pennsylvania State Univ., University Park). Trans. Met. Soc. AIME, 245: 436-7(Feb. 1969). (NYO-3560-14).

Compression tests were performed at room temperature on specimens of $HoZn_2$ prepared by powder metallurgy. Twinning was reported and additional twinning was observed to decrease with increased distance away from the fracture surface. No yielding is indicated, but a small amount of localized plastic deformation in $HoZn_2$ seems evident. (J.C.W.)

**18246** HYDROGEN EFFECTS IN REFRACTORY METALS. Chandler, W. T.; Walter, R. J. (Rocketdyne, Canoga, Park, Calif.). pp 197-249 of Refractory Metal Alloys. Metallurgy and Technology. Machlin, I. (ed.). New York, Plenum Press, 1968.

From Symposium on the Metallurgy and Technology of Refractory Metal Alloys, Washington, D. C. See CONF-680448.

The effects of hydrogen on the refractory metals molybdenum, tungsten, niobium, and tantalum are reviewed. Information on solubility, permeability, and diffusion of hydrogen in the refractory metals, refractory metal–hydrogen phase diagrams, and the effects of absorbed hydrogen and hydrogen environments on mechanical properties is presented. Molybdenum and tungsten have very low solubilities for hydrogen and are essentially unaffected by hydrogen. Niobium and tantalum can absorb large quantities of hydrogen and form hydrides, and are greatly embrittled by relatively small amounts of hydrogen at low temperatures. However, the solubility of hydrogen in niobium and tantalum decreases to low values above approximately 1600°F, the hydrides are stable only at relatively low temperatures, and relatively large quantities of hydrogen are required to cause embrittlement at elevated temperatures. Embrittlement of niobium and tantalum by hydrogen at room temperature and below is usually associated with hydride formation. No investigations have been made of the mechanism of embrittlement by hydrogen at higher temperatures. Niobium and tantalum specimens will fragment when cooled from elevated temperatures in hydrogen or, under certain conditions, when exposed to hydrogen at room temperature. (auth)

**18247** INTERACTIONS OF REFRACTORY METALS WITH ACTIVE GASES IN VACUA AND INERT GAS ENVIRONMENTS. Inouye, H. (Oak Ridge National Lab., Tenn.). pp 165-95 of Refractory Metal Alloys. Metallurgy and Technology. Machlin, I. (ed.). New York, Plenum Press, 1968.

From Symposium on the Metallurgy and Technology of Refractory Metal Alloys, Washington, D. C. See CONF-680448.

The interactions of refractory metals with active gases in vacuum and inert gas environments is reviewed. At temperatures from 600 to 2000°C and at pressures from $10^{-3}$ to $10^{-10}$ torr, contamination, degassing, decarburization, and sublimation reactions occur between the refractory metals and absorbed gases. The extent and kinetics of these reactions are governed by the deviation of the interstitial concentration of the refractory alloy from the equilibrium concentration dictated by the temperature and pressure of the active gas. The reaction rates in inert gases are equivalent to vacua of approximately $10^{-5}$ to $10^{-7}$ torr. These interactions can be reduced by minimizing the surface-to-volume ratio of the metal and minimizing the degree of equilibrium disparity. Added control is gained by the use of barrier foil envelopes and the use of low-pressure $CH_4$ to neutralize the oxidizing gases. (auth)

**18248** ALLOTROPY IN HAFNIUM OXIDE UNDER HIGH PRESSURE. Bocquillon, G.; Susse, C.; Vodar, B. (CNRS, Bellevue, France). Rev. Int. Hautes Temp. Refract., 5: 247-51(Oct.-Dec. 1968). (In French).

The polymorphism of hafnium oxide has been studied by quenching under pressure (≤60 kb) and 1600°C. An orthorhombic phase, parameters of which are a = 5.008 Å ± 0.006, b = 5.062 Å ± 0.006, and c = 5,223 Å ± 0.006 has been shown. The formation of this phase is improved by the presence of water and a minimal pressure of 15 kb. The tetragonal form of the oxide has not been quenched. The partial disagreement with recent works on $HfO_2$ is discussed. (tr-auth)

## *Radiation Effects*

*Refer also to abstract 17655.*

**18249** (ORNL-TM-2359) EVALUATION OF THE MOLTEN-SALT REACTOR EXPERIMENT HASTELLOY N SURVEILLANCE SPECIMENS: SECOND GROUP. McCoy, H. E. Jr. (Oak Ridge National Lab., Tenn.). Feb. 1969. Contract W-7405-eng-26. 69p. Dep. CFSTI.

The second group of Hastelloy N surveillance samples removed from the Molten-Salt Reactor Experiment have been examined. Two rods of standard Hastelloy N were removed from the surveillance position outside the core vessel and were exposed to the nitrogen plus 2 to 5% $O_2$ cell environment for 11,000 hr. Metallographic examination showed that the alloy was compatible with this environment, showing only superficial oxidation and no evidence of nitriding. These samples were exposed to a thermal fluence of $1.3 \times 10^{19}$ neutrons/cm$^2$, and the mechanical properties were altered appreciably. Both tensile and creep tests were run that showed significant changes in the mechanical properties, particularly the strain at fracture. These changes are in good agreement with those observed for materials irradiated in a helium environment in the Oak Ridge Research Reactor. Two rods of modified Hastelloy N containing small additions of titanium and zirconium were removed from the core surveillance facility with a thermal fluence of $4.1 \times 10^{20}$ neutrons/cm$^2$. These materials had not been annealed properly to put them in their most radiation-resistant condition, but test results on these materials indicated that they have slightly improved postirradiation mechanical properties and that their corrosion resistance is acceptable. (auth)

**18250** (ORNL-TM-2480) TRANSMISSION ELECTRON MICROSCOPY AND PLASTIC DEFORMATION IN NEUTRON-IRRADIATED NIOBIUM. Tucker, R. P. (Oak Ridge National Lab., Tenn.). Mar. 1969. Contract W-7405-eng-26. 311p. Dep. CFSTI.

Thesis. Submitted to Univ. of Tennessee, Knoxville.

Defect clusters and plastic deformation in neutron-irradiated polycrystalline and single-crystal niobium were studied by transmission electron microscopy (TEM) and tensile testing to determine the nature of radiation-produced defect clusters (spot damage), the crystal geometry and mechanism of dislocation channeling, the dose dependence of the yield stress, the influence of low-temperature post-irradiation annealing on the yield stress, and the temperature dependence of yielding. Niobium samples were neutron-irradiated at ~50°C for polycrystals, 90–110°C for single crystals to doses, $\Phi$, from $4 \times 10^{15}$ to $8 \times 10^{18}$ neutrons/cm$^2$ (E > 1 MeV). Defect clusters were observed by transmission electron microscopy in polycrystalline niobium over a range of doses from $2 \times 10^{17}$ to $4.4 \times 10^{18}$ neutrons/cm$^2$ (E > 1 MeV). Dislocation channels cleared of radiation-produced defect clusters were observed by TEM in polycrystalline niobium irradiated to doses greater than about $10^{18}$ neutrons/cm$^2$ and then deformed in tension. Mechanisms for the clearing of the defect clusters are described. The yield stress in single-crystal and polycrystalline niobium was found to be proportional to the square root of the dose for $\Phi \gtrsim 10^{18}$ neutrons/cm$^2$; at higher doses, the rate of hardening decreased markedly, i.e., a saturation effect was observed. Low-temperature post-irradiation annealing at 175°C and 300 to 400°C gave rise to further yield stress increases (radiation-anneal hardening). The temperature dependence of the yield stress is not substantially changed by irradiation to $2.8 \times 10^{17}$ neutrons/cm$^2$ for test temperatures from 93 to 298°K, which suggested that irradiation to this dose does not change the thermally-activated mechanism of deformation in single-crystal niobium. It is concluded that radiation hardening in niobium can be explained on the basis of the short-range elastic interaction between radiation-produced defect clusters visible by TEM and slip dislocation. (auth)

**18251** IN SITU EFFECTS OF PROTONS AND SOLAR ELECTROMAGNETIC ENERGY ON THERMAL CONTROL COATINGS. Fogdall, Lawrence B.; Cannaday, Sheridan S.; Brown, Richard R. (Boeing Co., Seattle). pp 110-14 of IES/AIAA/ASTM Third Space

Simulation Conference. Mt. Prospect, Ill., Institute of Environmental Sciences, 1968.

From 3rd Space Simulation Conference, Seattle, Wash. See CONF-680947.

New space simulation techniques are discussed, and results of proton and electromagnetic radiation effects tests on both diffuse and specular thermal control coatings are presented. A long-arc, water-cooled xenon source was employed to simulate the electromagnetic energy output of the Sun. By in situ spectral monitoring, this source was found to provide a smooth continuum in the ultraviolet wavelength region, approximating that of the Sun. A low energy particle accelerator generated protons of 20-keV energy for separate and combined proton-ultraviolet tests. Coatings studied included S-13G, $TiO_2$ in methyl phenyl silicone, leafing aluminum-phenylated silicone, flash aluminized lacquer, buffed aluminum, $SiO_2$ over aluminum, and $Al_2O_3$ over aluminum. A surprisingly wide range of thresholds for damage and rates at which degradation proceeded were seen in these tested coatings. Degradation from protons was characterized as being similar to that caused in some coatings by ultraviolet-rich electromagnetic radiation, and substantially different than degradation caused by incident electrons. Whereas in white coatings 50-keV electrons cause large, in-air-recoverable degradation to occur in the infrared region and slight damage in the visible region, 20-keV protons caused severe degradation in the visible region of S-13G and $TiO_2$-silicone and less damage in the infrared, at fluences less than $10^{16}$ protons/cm$^2$. Threshold for damage in the visible region was about $10^{14}$ protons/cm$^2$. Specular coatings and leafing aluminum strongly resisted degradation from proton radiation, degrading significantly only at $10^{17}$ protons/cm$^2$. Synergistic effects observed raise the question of standardizing practices of exposing coatings to simulated solar energy, and of sequencing combined-environment exposures of thermal control coatings, so that laboratory results are relevant to actual space environments encountered. (auth)

**18252** RADIATION RATE EFFECTS IN SPACE SIMULATION. Babjak, S. J.; Scannapieco, J. F.; Goldis, A. M. (General Electric Co., Valley Forge, Pa). pp 105-9 of IES/AIAA/ASTM Third Space Simulation Conference. Mt. Prospect, Ill., Institute of Environmental Sciences, 1968.

From 3rd Space Simulation Conference, Seattle, Wash. See CONF-680947.

Experiments with low energy electron irradiation over a wide flux range have shown that the effects of accelerated testing of thermal coatings with corpuscular radiation does not simulate real time effects. It has been shown that variations of incident flux on a $TiO_2$ plus silicone binder white thermal control coating will not cause equal amounts of degradation in the coating even though the integrated fluxes are the same. In addition, the relationship between electrons per cm$^2$ per sec and change of reflectance (measure of degradation) was an inverse one. This inverse relationship was studied in two sets of experiments, both of which showed that there was no measurable space charge buildup on the thermal control coating at high incident fluxes. It is therefore assumed that the degradation phenomena is reaction rate limited. If these results are predominant in other thermal control coatings, the large discrepancy between space simulated tests and flight acquired data can be significantly reduced. (auth)

**18253** IRRADIATION EFFECTS IN FORTIWELD STEEL CONTAINING DIFFERENT BORON ISOTOPES. Grounes, M. (Aktiebolaget Atomenergi, Studsvik, Sweden). J. Mater., 3: 614-28(Sept. 1968).

Fortiweld steel, a pressure vessel material for the Swedish Marviken reactor, was submitted to an extensive irradiation-effects program. Tension specimens and miniature impact specimens of the low-alloyed pressure vessel steel were irradiated at 265°C in the R2 reactor to 2 neutron doses, $6.5 \times 10^{18}$ n/cm$^2$ (>1 MeV) and $4 \times 10^{19}$ n/cm$^2$ (thermal) and also $9.0 \times 10^{18}$ n/cm$^2$ (>1 MeV) and $6 \times 10^{19}$ n/cm$^2$ (thermal). Material from 3 laboratory melts, in which the boron consisted of $^{10}B$, $^{11}B$, and natural boron, respectively, were investigated. The results both of tension tests and impact tests with miniature impact specimens showed that the $^{10}B$ alloyed material was changed more and the $^{11}B$ alloyed material was changed less than the material containing natural boron. At the higher neutron dose, the increase in yield strength (0.2% offset yield strength) was 11 kg/mm$^2$ in the material containing $^{10}B$ compared to 5 kg/mm$^2$ in the material containing $^{11}B$. The decrease in total elongation was 5 and 0%, respectively. The transition temperature was increased 190°C at the higher neutron dose in the $^{11}B$ alloyed material and 80°C in the material containing natural boron. (BBB)

**18254** SATURATION OF RADIATION HARDENING. Galligan, J. M. (Brookhaven National Lab., Upton, N. Y.). Phys. Lett., 28A: 609(Feb. 10, 1969).

A model of saturation of radiation hardening is given. This model suggests that saturation of the thermal hardening component should occur at different fluence levels than would the athermal component. (auth)

# Ceramics and Cermets

## *Preparation and Fabrication*

*Refer also to abstracts 17645 and 17669.*

**18255** (AI-CE-45) HEAVY WATER ORGANIC COOLED REACTOR. PRELIMINARY ANNULAR UC FUEL CASTING DEVELOPMENT. Katz, N. H. (Atomics International, Canoga Park, Calif. Combustion Engineering, Inc., Windsor, Conn. Nuclear Div.). Mar. 15, 1969. Contract AT(38-1)-430. 41p. Dep. CFSTI.

An exploratory casting program was conducted to determine the feasibility of casting hyperstoichiometric uranium carbide in the shape of rings, as fuel for application in advanced Heavy Water Organic Cooled Reactor (HWOCR) annular element designs. Unique mold gating systems were developed for both single- and multiple-cavity molds. This resulted in the successful arc casting of uranium carbide fuel rings and hollow cylinders of various outside diameters, ranging from $\frac{3}{4}$ to 3.5 in., all having a $\frac{1}{4}$-in. wall thickness, and lengths up to 6 in. The major problem areas pertinent to the development of a reliable multiple-cavity skull casting process for annular uranium carbide fuel have been isolated and analyzed. However, additional work is required to resolve existing problem areas and to develop advanced technology for a large-scale, economical, multiple-concentric-ring casting process for the advanced HWOCR concepts. (auth)

**18256** (GA-6233) ADVANCED, GRAPHITE-MATRIX, DISPERSION-TYPE FUEL SYSTEMS AND RESEARCH ON GRAPHITE. Annual Report, April 1, 1964–March 31, 1965. Bokros, J. C.; Goeddel, W. V.; Lonsdale, H. K.; Price, R. J.; Tully, G. R. Jr.; White, J. L.; Zumwalt, L. R. (Gulf General Atomic, Inc., San Diego, Calif.). July 20, 1965. Contract AT(04-3)-167. 186p. Dep. CFSTI.

The structures of pyrolytic carbons deposited in a fluidized bed are being characterized to establish the relations existing between bed deposition conditions, coating structure, and the physical and mechanical properties relevant to reactor performance. Studies are being extended to deposition temperatures greater than 1900°C. The property studies include measurements of the effects of annealing and irradiation on pyrolytic carbons. The rates of diffusion of thorium and uranium in pyrolytic carbons typical of those employed in graphite-matrix fuel systems are being determined. Particular emphasis is being given to determining the effect of coating structure on diffusion. The release of fission products through pyrolytic-carbon coatings typical of those employed in graphite-matrix fuel systems is being determined in an effort to relate release rates to coating structure. Methods of characterizing the degree of graphitization of carbons and graphitic materials are being investigated. The relations of physical properties such as Young's modulus and the dimensional changes under irradiation, to the preferred orientation of various graphitic materials are being studied. The process of hot-working graphitic materials is being investigated, with current emphasis on evaluating the variables of pitch content and additives in the graphite bodies. (J.C.W.)

**18257** (LIB/Trans-189) STUDY OF THE PREPARATION OF SINTERABLE URANIUM DIOXIDE FOR THE FABRICATION OF FUEL FOR THE EL-4. Delmas, R.; Holder, J. Translated by M. A. Hintze (Australian Atomic Energy Commission Research Establishment, Lucas Heights), from pp 95-108 of New Nuclear Materials Including Non-Metallic Fuels, IAEA Conference Proceedings, Prague, 1963, Vol. I. 14p. Dep.

An abstract of this paper, prepared from the original language, appeared as NSA 17: 33271.

**18258** (ORNL-tr-2098) PREPARATION AND HOT-PRESSING BEHAVIOR OF URANIUM MONONITRIDE. Thuemler, Fritz; Ondracek, Gerhard; Dalal, Kirit. Translated for Oak Ridge National Lab., Tenn., from Z. Metallk., 56: 535-42(1965). 28p. Dep. CFSTI.

An abstract of this paper, prepared from the original language, appeared as NSA 20: 799.

**18259** (PNCT-AR-67) ANNUAL REPORT OF TOKAI WORKS, APRIL 1, 1967–MARCH 31, 1968. (Power Reactor and Nuclear Fuel Development Corp., Tokai (Japan)). July 1968. 66p. Dep.

The development of nuclear fuels for power reactors including the development of mixed uranium and plutonium oxide fuels for fast breeder and advanced thermal reactors and the development of spent fuel reprocessing technology are reported. Plutonium fuel development and design, Zircaloy sheath tubing inspection by ultrasonics, and site health and safety are discussed. (F.S.)

**18260** ISOSTATIC PRESSING FOR UNIFORM DENSITY. Precis. Metal, 25: 39-40(Dec. 1967).

Precision tungsten carbide parts were produced by isostatically pressing tungsten carbide powder into billets on an isostatic press which has a working pressure of 25,000 psi. The green density of the billets produced is 121 to 130 g/in$^3$. After pressing, the billets were sawed into various sizes and machined to the desired shape. Sintering was done at 2900°F and results in a volume shrinkage of about 22% from the pressed and machined billet size. The shrinkage is uniform in all directions. (F.S.)

**18261** IMPROVEMENTS IN ENTRAINED FLUIDIZED BED COATING APPARATUS AND METHOD THEREOF. (to United Kingdom Atomic Energy Authority). British Patent 1,144,320. Mar. 5, 1969. Priority date Apr. 5, 1966, United States.

Apparatus is described for coating discrete particles, such as nuclear fuel particles. The principal application is to the pyrolytic carbon coating of oxide and carbide fuel particles, on the routine kilogram scale and for particles of diameter up to 1000 $\mu$. The apparatus comprises a cylindrical, elongated, vertically extending vessel adapted to contain a bed of solids; an inwardly tapered lower section is provided, together with a vertically extending open-ended insert disposed concentrically within the lower portion of the vessel, the insert extending downwards into the conical region of the tapered lower section and terminating immediately above the walls of the tapered section, forming a gap therebetween. A centrally disposed gas inlet is provided, connected to the bottom of the tapered lower section, for passage of a continuous gas stream upwardly into the interior of the lower section and through the insert, thereby providing a particle conveyance pattern during fluidisation and entrainment consisting of a vertical upflow through the insert and a downward return along the annulus between the insert and the vessel walls. Gas outlet means are provided in the upper portion of the vessel, together with heating means external to the vessel for heating the vessel to the required decomposition temperature, and means for discharge of the bed from the vessel. The method for coating nuclear fuel particles is described in detail. Coating may be achieved with a carrier gas comprising methane and argon at a flow rate of 45 l/min. and at a temperature of 2100°C on thoria particles. (UK)

**18262** THERMAL INSULATION. Milner, Malcolm John (to English Electric Co., Ltd.). British Patent 1,144,643. Mar. 5, 1969. Filed June 10, 1965.

A method of forming a thermally insulating layer on a surface is described. The method comprises making a viscous mixture of exfoliated vermiculite with a solution of a binding agent such as silicate of sodium, potassium, calcium or lithium, spraying the mixture on to the surface to be insulated, and then applying $CO_2$ so as to cause the coating to solidify. It is preferred to dispose the mixture between the said surface and a cover plate with the $CO_2$ therebetween. An application is to the interior surface of a nuclear reactor concrete pressure vessel. The method may also be applied to steel. (UK)

**18263** IMPROVEMENTS IN OR RELATING TO MOULDS FOR USE IN METAL CASTING. Dunlop, Adam (to Imperial Metal Industries (Kynoch) Ltd.). British Patent 1,144,174. Mar. 5, 1969. Filed Mar. 19, 1966.

Reference is made to BP 1,140,451 in which a mold suitable for highly reactive metals such as Ti and Zr is described, the mold being made of refractory material impregnated with carbon and the carbon impregnant being obtained by the dissociation of liquid or gaseous hydrocarbons. In the present specification the carbon is obtained by carbonising furfuryl alcohol. Details are given for fabricating such a mold. (UK)

**18264** SOL-GEL PROCESS FOR PRODUCTION OF SPHERICAL (Th,U)$O_2$ PARTICLES. Krabe, J.; Mueller, F. Atomwirt., Atomtech., 14: 86(Feb. 1969). (In German).

In the processing of U–Th fuel elements by the chloride volatility method, the metals are accumulated as chlorides. These are to be converted into spherical (Th,U)$O_2$ particles having a specified weight ratio of Th and U. A method based on the sol-gel techniques is described which produces good results. (tr-auth)

**18265** RADIOLOGICAL SHIELD FOR PROTECTION AGAINST NEUTRONS AND GAMMA-RADIATION. (to Instytut Badan Jadrowych). British Patent 1,145,042. Mar. 12, 1969. Priority date Mar. 13, 1965, Poland.

A radiological shield for gamma and neutron protection is described that is fabricated of high density material coated by plasma spraying with a refractory material having thermal neutron absorption properties. Refractory materials which may be used include the carbides of B, Cd, Eu, Gd, Hf, and In. The materials are fused in an electric arc and sprayed or sputtered by a plasma jet to form a coating of the desired thickness. (F.S.)

**18266** CAVITIES IN EVAPORATED THIN FILMS OF $NpO_2$. Douglass, Dana L.; Bronisz, S. E. (Los Alamos Scientific Lab., N. Mex.). Thin Solid Films, 2: 535-6(Dec. 1968).

Films were prepared by evaporation of $NpO_2$. They were composed of randomly oriented acicular grains 50 to 100 Å in size. Heating by an electron beam caused the grains to become equiaxed and, if more than one film thickness, sintered to form a single layer. The grain boundaries became grooved in annealing and these grooves were trapped inside the single layer to become geometric cavities. (M.C.G.)

**18267** METHOD FOR PRODUCING NUCLEAR FUEL RODS. Takahashi, Shuichiro (to Mitsubishi Atomic Power Industry, Inc.). Japanese Patent 1968-26677. Nov. 15, 1968. Filed Nov. 18, 1965.

A method is proposed for producing $UO_2$ fuel rods using the powder. It has the advantages such as elimination of the use of bonding and lubricating agents and the sintering process; rapid process of obtaining high density fuel rods. To obtain a fuel rod, the powder of nuclear fuel is first packed in a thin-walled container and processed by the extrusion of hydrostatic superpressure–high pressure, to give it the desired shape. With the same procedure as above using powdered $\alpha UO_{2+x} + \beta UO_{2-y}$ $\alpha$ and $\beta$ are constants determined by the characteristics of the powder, $0 \leqq x < 1$, $0 < y \leqq 2$. (NSA of Japan)

## *Properties Evaluations*

*Refer also to abstract 17397.*

**18268** (BMwF-FBK-68-35) BEHAVIOR OF REACTOR FUELS AT ELEVATED TEMPERATURES. Lindner, R. (Technische Hochschule, Brunswick (West Germany). Institut fuer Kern- und Radiochemie. European Atomic Energy Community, Ispra (Italy). Joint Nuclear Research Center). Aug. 1968. 14p. (In German). Dep.

The diffusion parameters of actinide elements in special nuclear materials, like uranium carbide, thorium metal and Zircaloy, were determined. The results are summarized. The preparation of thorium-protactinium alloys on a micro-scale, using the Van Arkel process, was investigated. For the first time an alloy containing 15% of Pa was successfully prepared. Preliminary experiments with the aim of determining directly the oxygen solubility in stoichiometric U(C,O)-phase using a high temperature x-ray camera are described. (auth)

**18269** (GA-7519) ADVANCED GRAPHITE FUEL SYSTEMS. Quarterly Progress Report for the Period Ending November 14, 1966. Bokros, J. C.; Engle, G. B.; Price, R. J.; White, J. L. (General Dynamics Corp., San Diego, Calif. General Atomic Div.). Dec. 9, 1966. Contract AT(04-3)-167. 62p. Dep. CFSTI.

Results of research on the structure and properties of carbons and graphites and the effects of irradiation on these structures and properties are reported. Micrographic studies of a coal-tar pitch heat-treated to temperatures of 400 to 700°C are described. Experiments have been initiated to identify the various structural states of the carbon comprising conventional binder-filler bodies. A series of molded bodies with pitch-binder contents in the range 10 to 50 wt % have been prepared and will be irradiated in the range 1000 to 1400°C to a dose of ~$3.5 \times 10^{21}$ nvt (E > 0.18 MeV). Coefficients of thermal expansion of nongraphitic carbons have been measured perpendicular to the deposition plane for pyrolytic carbons with Bacon anisotropy factors in the range 1.3 to 3.0 and densities in the range 1.5 to 2.1 g/cm$^3$. Radiation induced dimensional changes in single-phase carbons and graphites are analyzed to determine the relations between the dimension stability of these materials in fast neutron fluxes and their crystalline perfection. Annealing at 1400°C for 1 hr produced increases in the density and apparent crystallite size of a pyrolytic carbon containing 6.7% Ti deposited at 1225°C. (J.C.W.)

**18270** (GAMD-8724) EFFECT OF CERTAIN PROCESSING VARIABLES ON CORE DIFFUSION INTO ENRICHED FUEL PARTICLE COATINGS. Steward, K. P. (Gulf General Atomic, Inc.,

San Diego, Calif.). June 27, 1968. Contract AT(04-3)-633. 17p. Dep. CFSTI.

The amount of core diffusion present in the batches of enriched fuel particles fabricated for the P20, P21, and P22 capsules has been quantitatively estimated from radiograph slides. Only two core materials were used for all the batches, and it is therefore possible to relate the resulting diffusion to processing parameters in several cases. It is concluded that triplex isotropic coated (TRISO-II) particles show much less diffusion than TRISO-I, and likewise batches with low temperature isotropic (LTI) outer coatings show much less diffusion than those with high temperature isotropic (HTI). Diffusion is also less in TRISO-I particles with SiC deposited at 1400 rather than at 1500°C, although fast deposition of SiC at 1500°C in the initial stages appears to eliminate subsequent diffusion. In TRISO-II particles, an HTI inner layer causes diffusion, whereas LTI does not. A core seal provides an effective barrier to core diffusion during coating fabrication, and an inner isotropic layer appears to provide a further barrier. (auth)

**18271** (LA-4077) EXTRUDED CARBIDE-GRAPHITE COMPOSITES. Riley, R. E.; Richerson, N. K.; Schell, D. H. (Los Alamos Scientific Lab., N. Mex.). Oct. 15, 1968. Contract W-7405-eng-36. 14p. Dep. CFSTI.

Preliminary data on the mechanical and physical properties of extruded carbide-graphite composites are presented. The results include the effect of carbide content on the room-temperature compression and flexure strength and on resistance to deformation at elevated temperatures. Also presented are data on room-temperature electrical resistivity, thermal expansion to 2000°C in the across-grain and with-grain directions, modulus of elasticity as a function of temperature, and metallography. (auth)

**18272** (ORNL-tr-3019) CONTRIBUTION TO THE STUDY OF THE SYSTEM (U,Pu)C,N. Lorenzelli, Robert (Commissariat a l'Energie Atomique, Fontenay-aux-Roses (France). Centre d'Etudes Nucleaires). Translated for Oak Ridge National Lab., Tenn., from report CEA-R-3536. 71p. Dep. CFSTI.

An abstract of this paper, prepared from the original language, appeared as NSA 22: 52259. (R.C.K.)

**18273** STUDIES OF TEMPERATURE DEPENDENCE OF THERMAL CONDUCTIVITY OF ALLOYED CERIUM SULFIDE IN HOMOGENEOUS REGIONS. Goryachev, Yu. M.; Kutsenok, T. G. (Inst. of Problems in Material Studies, Kiev). Fiz. Tekh. Poluprov., 3: 277-8(Feb. 1969). (In Russian).

Studies of cerium sulfide thermal conductivity investigated at 300 to 1200°K with specimens of $CeS_{1.5}$, $CeS_{1.4}$, $CeS_{1.36}$ and $CeS_{1.4}$ + 1.5 at. % Me (where Me is Zr, Nb, Mo, Hf, Ta, and W) showed that with the rise of the temperature the thermal conductance diminished which may be explained by contribution of the phonon component of the conductivity. The increase of the conductivity from $CeS_{1.5}$ to $CeS_{1.36}$ was probably related to the reduced anharmonicity in lattice oscillation as it filled the vacancies in cerium sublattice. Both phenomena are in agrument with the thermal expansion of the specimens. (R.V.J.)

**18274** THE CONNECTION BETWEEN HARDNESS, ABRASIVE POWER, CRYSTAL STRUCTURE, AND ELECTRON STRUCTURE OF REFRACTORY COMPOUNDS. Stasovskaya, V. V. Tr. Metrol. Inst. SSSR, 91: No. 151, 170-3(1967). (In Russian).

The abrasive properties of a number of solid refractory compounds were studied in relation to grain size. Examples are quoted for V borides, Si carbide, and Ta carbide. The abrasive power increases with grain size and for borides with increasing B content. (Referativnyi Zh.)

**18275** HYDROGEN EMBRITTLEMENT: A RESISTOMETRIC STUDY OF NIOBIUM(COLUMBIUM)-HYDROGEN ALLOYS. Westlake, D. G. (Argonne National Lab., Ill.). Trans. Met. Soc. AIME, 245: 287-92(Feb. 1969).

Resistance was measured as a function of temperature, 77 to 350°K, for niobium with hydrogen concentrations up to 3.76 at. %. Cooling curves exhibited a discontinuity in slope that was attributed to the initiation of hydride formation. A thermal hysteresis was explained in terms of diffusion and the effects of mechanical constraint on nucleation and growth. The heat of solution of hydrogen in saturated Nb-H solid solution was 2.737 ± 0.045 kcal per g-atom, including an unknown stress contribution. The critical temperatures for hydride formation during cooling and for embrittlement are correlated but not coincident. This, too, has been explained in terms of mechanical constraint and stress-induced transformation. (auth)

## *Structure and Phase Studies*

**18276** (LA-4010) AUGER ELECTRON STUDIES OF SURFACES: URANIUM DIOXIDE, URANIUM, GRAPHITE, 300 SERIES STAINLESS STEEL, AND NIOBIUM. Campbell, Bruce D. (Los Alamos Scientific Lab., N. Mex.). Aug. 1968. Contract W-7405-eng-36. 12p. Dep. CFSTI.

The Varian low energy electron diffraction (LEED) system was successfully modified to produce Auger electron spectra from solid surfaces. The Auger spectra from cleaned (111) and (110) surfaces of $UO_2$ indicated that no large amount of surface contamination was present. When surface superstructures were formed by oxygen exposures, the Auger spectra indicated that oxygen was in fact the substance which caused the new structure. The Auger spectra from clean uranium metal resembled that from $UO_2$, except for the greatly diminished intensity of the oxygen peak and different relative intensities of the four peaks between 50 and 100 eV. Also, a large sulfur peak at 150 eV was always present for the annealed uranium surface. Although the sulfur was removed by argon-ion bombardment, it diffused to the surface again when the sample was annealed. Polycrystalline samples of niobium and stainless steel also exhibited segregation of sulfur at the surface. As with uranium, the sulfur could be removed by ion bombardment but returned on heating. A sample of graphite exhibited only the expected carbon peak. However, after argon-ion bombardment, an intense argon peak was observed, indicating detection of argon imbedded in the lattice. (auth)

**18277** (LIB/Trans-185) THE SINTERING KINETICS AND POWDER PROPERTIES OF MgO AND $UO_2$. Krauth, A. Translated by Annaliisa Janov (Australian Atomic Energy Commission Research Establishment, Lucas Heights), from Ber. Deut. Keram. Ges., 44: 554-9(Nov. 1967). 17p. Dep.

An abstract of this paper, prepared from the original language, appeared as NSA 22: 11082. (L.C.L.)

**18278** EXISTENCE OF A SUPERSTRUCTURE IN SUBSTOICHIOMETRIC THORIUM CARBIDE: $ThC_{0.76}$. Lorenzelli, R.; de Dieuleveult, I. (CEN, Fontenay-aux-Roses, France). J. Nucl. Mater., 29: 349-53(Mar. 1969). (In French).

The existence of a superstructure probably due to an ordering of the carbon atoms was proven for the composition $ThC_{0.76}$. This superstructure is shown by x rays by the appearance of supplementary rays of very low intensity. The order-disorder transition is very clearly visible on the thermal dilation curves obtained by x rays. The transition occurs between 750 and 800°C and the transition temperature is of the same order of magnitude as that found by Satov (830°C) by thermodynamic, resistivity, and thermal dilation measurements; on the contrary, the thermal dilation coefficient of the disordered phase is much larger than that found by Satov. (tr-auth)

**18279** THE FORMATION AND STABILITY OF GROUP IVA CARBIDES AND NITRIDES IN MOLYBDENUM. Ryan, N. E.; Martin, J. W. (Oxford Univ.). J. Less-Common Metals, 17: 363-76(Apr. 1969).

The formation of the Group IVA carbide and nitride phases in molybdenum by arc melting simple ternary alloys has been demonstrated. The threshold solute metal-interstitial atom ratios have been determined for the complete formation of the Group IVA compounds in preference to molybdenum phases. Increasing solubility with increasing temperature, up to 2100°C, demonstrates that all these alloys show potential precipitation hardening characteristics. In some alloys (chiefly Mo-Ti-C) reversion to $Mo_2C$ occurs above 1600°C. (auth)

**18280** DETERMINATION OF THE STRUCTURE OF THE ZIRCONIUM SUBOXIDE $Zr_3O$ BY ELECTRON DIFFRACTION. Steeb, S.; Riekert, A. (Max-Planck-Institut fuer Metallforschung, Stuttgart). J. Less-Common Metals, 17: 429-36(Apr. 1969). (In German).

When chemically thinned single crystals of zirconium were investigated by electron diffraction (50 kV) during isobaric treatment with oxygen at $5-10^{-4}$ Torr at a temperature of 400°C, superstructure diagrams were obtained which are attributed to the new phase $Zr_3O$. Interpretation of the diffraction patterns showed that $Zr_3O$ crystallizes in the hexagonal system with $a = 16.16$ Å (corresponding to $5a_{Zr}$) and $c = 5.148$ Å (corresponding to $c_{Zr}$) and possesses the composition $Zr_{48}O_{14}$. In the super-cell in each case six oxygen atoms form a ring, a total of four such rings forming the structure of the super-cell. A summary is also given of all known Zr-O compounds. The mean atomic volumes of these phases, when plotted against the oxygen atom concentration, lie on a smooth curve. (auth)

**18281** SiC PHASE IN THE SYSTEM Si-$B_4C$-C. Shaffer, Peter T. B. (Carborundum Co., Niagara Falls, N. Y.). Mater. Res. Bull., 4: 213-20(Mar. 1969).

The structure of the SiC phase in the system silicon carbide-boron carbide-carbon has been studied at 2200 to 2550°C. The solubility of boron in α-SiC at 2450 to 2500°C was shown to be less than 0.2 wt. %, while the solubility of silicon in boron carbide,

although it could not be determined quantitatively, is extensive. Boron saturated $\alpha$-SiC and a phase having the general formula $B_{12}(Si,C,B)_3$ are stable in contact with a liquid phase above a eutectic temperature of 2245°C. The eutectic corresponds to a molar ratio of 3 SiC to 7 $B_4C$ plus carbon. No phases harder than $B_4C$ were found. (auth)

### *Radiation Effects*

*Refer also to abstracts 18256, 18259, and 18269.*

**18282** (HPR-105) IFA-27 EXPERIMENT TO STUDY VIBRATORY COMPACTED $UO_2$ IRRADIATION PERFORMANCE. Sieber, R. (Nuklear-Chemie und-Metallurgie G.m.b.H., Wolfgang bei Hanau (West Germany)). Jan. 1969. 40p.

The experimental fuel assembly IFA-27 was irradiated in the HBWR. The experimental assembly contained 4 vibratory compacted and 3 pelletized $UO_2$-fuel rods with Zircaloy-2 cladding. The seven rod cluster with a hexagonal lattice and a pitch of 23 mm was designed to produce an average of 600 W/cm fuel length. After 9 days of operation at average power levels up to 663 W/cm, cladding failures occurred on the vibratory compacted fuel rods. After an additional operation for 6 days at power levels up to 683 W/cm all 4 vibratory compacted fuel rods had failed. A visual inspection of the fuel rods revealed a total of eleven similar cladding failures. In all cases the failures were associated with extremely localized cladding expansions which ranged approximately from 0.3% to 1.9% of the original outer diameter. The cladding defects are explained as the consequence of localized hydrogen pick-up at the inner cladding surface and the action of a mechanical load on the cladding. The fact that none of the three remaining pelletized fuel rods (which were manufactured from identical starting materials) failed, suggests that the observed failures are inherent to this type of vibratory compacted fuel rods. (auth)

**18283** (ORNL-TM-2475) HIGH-TEMPERATURE FAST-NEUTRON IRRADIATION OF PYROLYTIC-CARBON-COATED $ThO_2$ MICROSPHERES. Hewette II, D. M. (Oak Ridge National Lab., Tenn.). Mar. 1969. Contract W-7405-eng-26. 16p. Dep. CFSTI.

The effects of fast-neutron damage alone on four types of pyrolytic-carbon coatings with spherical geometry were determined. The coatings, which ranged in density from 1.74 to 2.07 g/cm$^3$ and had Bacon anisotropy factors from 1.0 to 1.4, were irradiated in the Dounreay Fast Reactor to $4.5 \times 10^{21}$ neutrons/cm$^2$ (>0.18 MeV) at about 1200°C. A porous buffer layer prevented interaction between the coating and the sol-gel $ThO_2$ kernels. Essentially no fissioning occurred in the $ThO_2$ in the fast-neutron spectrum. It was found that only the coatings with the highest anisotropy factor failed. Coatings with an initial density of 1.8 g/cm$^3$ or less densified while coatings with an initial density of 1.9 g/cm$^3$ or greater swelled. Metallographic examination revealed that the preferred orientation increased in the coatings that densified. These changes must be considered in mathematical models describing coated-particle behavior. (auth)

**18284** RADIOINDUCED PHASE TRANSFORMATIONS IN THE FERROELECTRIC TYPE $BaTiO_3$. Kuz'min, I. I.; Solov'ev, S. P.; Zakurkin, V. V. (Inst. of Physics and Chemistry, Moscow). Izv. Akad. Nauk SSSR, Ser. Fiz., 33: 354-60(Feb. 1969). (In Russian).

Reversible and irreversible phase transformations induced by $\gamma$ and fast-electron irradiation and by fast neutrons are investigated. The reversible radioinduced effects and mechanism of phase transformation were studied with standard specimens of $BaTiO_3$ and $PbTiO_3$ 0.4 to 0.5 in diameter and 5 to 7 mm long irradiated in a WWR reactor with various doses of fast neutrons (from $10^{17}$ to $8 \times 10^{19}$ n. cm$^{-2}$. It was shown that the ratio of cell parameters c/a for $BaTiO_3$ diminished, transforming the tetragonal lattice into cubic at doses $\sim 7 \times 10^{18}$ n. cm$^{-2}$, and in the $PbTiO_3$ specimen the c/a increased from the initial 1.06 to 1.12 at irradiation dose of $3.8 \times 10^{17}$ n. cm$^{-2}$. The results indicated that the materials of $BaTiO_3$ type exposed to irradiation behave as molecular compounds with a dipole structure with irregular chemical bonds. inside and between the layers. Hence, deformations induced in these materials by irradiation, heating, electric field, and pressure are related to the weak chemical bonds. (R.V.J.)

## Plastics and Other Materials

*Refer also to abstracts 17487, 17701, 17921, and 19464.*

**18285** (BMI-1855) HEAT-RESISTANT CONCRETE FOR PRESTRESSED-CONCRETE-PRESSURE-VESSEL (PCPV) REACTORS. PHASE I REPORT. A STUDY OF THE EFFECTS OF ELEVATED TEMPERATURES ON PORTLAND CEMENT CONCRETE AS RELATED TO ITS USE IN A PRESTRESSED-CONCRETE PRESSURE-VESSEL REACTOR. Birkimer, Donald L.; Lankard, David R.; Fondriest, F. Frederick; Snyder, M. Jack (Battelle Memorial Inst., Columbus, Ohio). Jan. 1, 1969. Contract W-7405-eng-92. 148p. (EURAEC-2084). Dep. CFSTI.

The results of an investigation concerning the effects of heat exposure on portland cement concrete as related to its use in a prestressed concrete reactor pressure vessel are described. Two structural grade concretes were exposed to temperatures up to 500°F both at atmospheric pressure and under saturated steam pressure. The concretes were then studied to establish the nature of changes which occurred in the compressive strength, flexual strength, and modulus of elasticity as a result of the imposed test conditions. The effects of exposure to elevated temperatures on the mineralogical makeup and microstructure of the concretes were also studied. In addition, the effects of exposure to elevated temperatures on time-dependent deformations in concrete and on moisture migration in mass concrete were investigated. It was established that the effects of heat exposure on the structural properties of the concretes were quite dependent on their moisture content at the time of heating and/or testing. In general, deteriorations in the structural properties were observed under all heating conditions although the degree of deterioration was considerably worse if the moisture in the concrete was retained during heating and/or testing. It is suggested that the changes observed in the structural properties on heating at atmospheric pressure were primarily related to the loss of free water from the concrete. Property changes observed in concrete heated under saturated steam pressure were primarily related to concomitant changes in the mineralogy of the cementitious phases. It was shown that time-dependent deformations can occur in heated, stressed concrete which, because of the circumstances under which they occur, must be distinguished from time-dependent deformations which occur in stressed concrete at normal use temperatures (generally referred to as creep). The sources of deformation operative in heated, stressed concrete are interdependent. The magnitude and sign of the cumulative deformation in a heated and stressed concrete member was shown to be dependent on the time in the specimen's heating history at which the stress was applied. Studies of moisture migration in mass concrete were carried out using a six-foot diameter concrete sphere heated at its geometrical center. It was indicated that temperatures up to 250°F in the sphere's center did not influence the rate of moisture loss from the outside surface of the sphere over the duration of the test (43 weeks). Recommendations are presented regarding temperature limitations of portland cement concrete in PCPVR applications. Suggestions for future research are also given. (auth)

**18286** (EUR-4094) MICROGRAPHIC STUDY OF CARBONIZATION AND GRAPHITIZATION OF AN EXTRACTED COAL-TAR PITCH. White, J. L.; Dubois, J.; Souillart, C. (European Atomic Energy Community, Petten (Netherlands). Joint Nuclear Research Center). Jan. 1969. 24p. Dep.

Polarized-light micrography has been employed to investigate the microstructures formed in the carbonization and graphitization of a coal-tar pitch from which the insoluble particles have been removed by solvent extraction. Prominent features in the polarized-light extinction contours are the nodes and crosses, which are identified as four types of linear defects in the stacking of the aromatic layer planes. The coalescence process produces mostly cross-type stacking defects, but the deformation of the plastic mesophase caused by the percolation of gas bubbles results in an abrupt increase in the number of stacking defects and the formation of highly oriented regions with many folds in the layer planes. The principal effects of further heat treatment may be summarized as hardening and formation of shrinkage cracks, fold-sharpening, and finally the formation of mosaic blocks and kinks. By relieving boundary restraints and providing void space for small displacements of bulk material, the process of shrinkage cracking appears to be an essential precursor to fold-sharpening. In this latter process, the curved layer planes in the folds adjust to form sharp and approximately linear boundaries which may be twin boundaries in the ideal case. At temperatures near 3,000°C, mosaic blocks and kinks are formed on a fine scale as the final step in graphitization. (auth)

**18287** PRELIMINARY GAS PERMEATION MEASUREMENTS ON PLASTICS FOR USE AS CONCRETE CONTAINMENT VESSEL LINERS. Epstein, Leo F.; Hall, T. C. Jr.; Mills, S. Edwin (General Electric Co., Pleasanton, Calif.). Nucl. Eng. Design, 8: 345-59(Sept.-Oct. 1968).

Exploratory measurements have been made on the gas permeation characteristics of organic polymeric materials suitable for use as liners for concrete containment structures. Two plastics were studied, a modified polyvinyl chloride and a chlorosulphonated polyethylene, with air, nitrogen, oxygen, krypton, and xenon. The

observations were made at temperatures from about 25 to 80°C in order to establish an energy of activation for the permeation process. The use of plastics as liners for concrete reactor containment structures, and a calculation of expected leakage rates, is discussed. For reasonable film thicknesses, fission gas leak rates of a few hundredths of a percent per day can be anticipated. (auth)

**18288** LOW RADIOACTIVITY CONCRETE. Wollenberg, H. A.; Smith, A. R. (Univ. of California, Berkeley). J. Mater., 3: 757-9(Dec. 1968).

Concrete as a shield against radioactivity in low-background counting facilities must possess adequate thickness and density to shield out extraneous radioactivity. The concrete must be low in radioactivity the primary concern being the concentrations of K, U, and Th in aggregate and cement materials. An examination was made of possible sources of low radioactivity aggregate and portland cement for construction of a concrete low-background structure at the Lawrence Radiation Lab. Besides the aggregate and cement, the radioactivities of sources of water, reinforcing steel, and concrete additives must be considered. Radioactive contamination from mining and handling of concrete ingredients and placing of the concrete must be considered. In addition to the Lawrence Radiation Lab. facility, low-background facilities incorporating concrete in the shielding structure have been constructed, under construction, or being planned at the Franklin Inst., Brookhaven National Lab., San Francisco General Hospital, and the Oak Ridge Inst. of Nuclear Studies. With respect to shielding and low radioactivity, it was found that concrete can successfully compete with steel; also, concrete is about ¼ as expensive as low-radioactivity steel on an installed-cost-per-unit-area basis. (BBB)

# PHYSICS (GENERAL)

## Astrophysics and Cosmology

*Refer also to abstracts 18401–18403.*

**18289** (CONF-671217–, pp 287-369) ASTROPHYSICS: STELLAR PHYSICS. (Department of Atomic Energy, Bombay (India). Cosmic Ray Committee).

Fifteen papers are presented on (1) radio emission from supernova remnants, (2) relativistic astrophysics and gravitational collapse, (3) magnetostatic stellar corona, (4) existence of SH in solar atmosphere, (5) solar radio spectroscope at Ahmedabad, (6) Rayleigh scattering cross sections of He, C, N, and O, (7) molecular ratios as indicators of elemental abundance ratios, (8) convective processes in late-type stars, (9) Nova Delphini 1967, (10) spectra of radio sources Cygnus Loop and IC 443, (11) variation of electronic charge with cosmic time, and (12) synchrotron radiation from trapped electrons in the Van Allen belt. (M.O.W.)

### Cosmic Ray Exposure Ages

*Refer also to abstract 18452.*

**18290** MASS SPECTROMETRIC ELEMENTAL AND ISOTOPIC ABUNDANCE ANALYSES FOR STUDY OF THE HISTORY OF METEORITES AND THE PLANETARY SYSTEM. PART II. Voshage, Hans (Max-Planck-Institut fuer Chemie, Mainz). J. Mass Spectrom. Ion Phys., 1: 237-81(Aug. 1968). (In German).

A review of the techniques of age determination of meteorites by physical geochronology is given. Radionuclides discussed include $^{238}U$, $^{235}U$, $^{232}Th$, $^{187}Re$, $^{87}Rb$, and $^{40}K$. Advantages and difficulties of using the $^{238}U/^{206}Pb$, $^{235}U/^{207}Pb$, $^{232}Th/^{208}Pb$, $^{187}Re/^{187}Os$, $^{87}Rb/^{87}Sr$, and $^{40}K/^{40}Ar$ or $^{40}K/^{40}Ca$ ratios for age determinations are noted. Application of these methods to meteorite age determination and comparison with the $^{3}He/^{3}H$ ratio results are illustrated. Implications of the results for systematic studies of evolution of the Universe are discussed; Fe meteorite classification in particular is detailed. Categorization of chondrite meteorites by such studies into material of lunar and other origin (including the surface of Mars) will be tested by future manned space studies. The number of references totals 318. (BBB)

**18291** MASS SPECTROMETRIC ELEMENTAL AND ISOTOPIC ABUNDANCE ANALYSIS IN THE INVESTIGATION OF THE HISTORY OF METEORITES AND OF THE SOLAR SYSTEM. Voshage, Hans (Max-Planck-Institut fuer Chemie, Mainz). J. Mass Spectrom. Ion Phys., 1: 157-90(June 1968). (In German).

Exploration of the history of meteorites and of early history of the solar system by elemental and isotopic abundance analysis of meteoritic matter by mass spectrometry is reviewed. Application of the methods of physical geochronology to meteorites has shown that meteoritic matter is older than any terrestrial rock. The close relation of meteorites with the early history of the solar system is demonstrated by certain isotopic anomalies found in meteoritic xenon which are due to the decay of extinct radionuclides. By studying these anomalies the thermonuclear processes of nucleosynthesis in stars by which planetary matter was produced can be dated and explored. Investigations by mass spectrometry have also contributed toward a solution of the ancient question of the origin of meteorites, that is, to the question of the meteorite parent bodies. In spite of the large amount of experimental data accumulated so far, there remain, however, many unsolved problems. The field of meteoritics and techniques of rare-gas analysis are considered, as well as a review of recent investigations undertaken in order to explore the very early history of the solar system and to test various theories of nucleosynthesis. Radioactive dating of meteorites, research on primordial rare gases, and the effects of the cosmic-ray particle irradiation of meteorites in interplanetary space are also discussed. (BBB)

### Stars

*Refer also to abstract 18901.*

**18292** (AD-674630) EVOLUTION OF A 30 SOLAR MASS, POPULATION I STAR. Report No. Scientific-4. Schindler, Alan M. (Brandeis Univ., Waltham, Mass. Dept. of Physics). July 1968. Contract AF19(628)-4019. 176p. (AFCRL-68-0364). CFSTI.

The problem of stellar evolution can be divided into three phases: the formation of stars from the interstellar medium; the evolution of stars through various stages of expansion and contraction, increasing and decreasing brightness and temperature, and through various changes in chemical constituents, the question of the final stellar state. The second phase of the problem is investigated for a 30-solar-mass star of Population I. (USGRDR)

**18293** CONDENSED OBJECTS IN THE CRAB NEBULA. Burbidge, G. (Univ. of California, San Diego); Hoyle, F. Nature (London), 221: 847-8(Mar. 1, 1969).

It is stated that it is difficult to understand the evolution of the Crab and its high-energy particle content on the assumption that all the energy was injected at the time of the supernova outburst about $10^3$ years ago. There is evidence of continuous activity, and a suggestion that parts of the flux of high-energy electrons responsible for the radio and optical synchrotron radiation have lifetimes short compared with the time which has elapsed since the explosion. If all the energy released in a supernova explosion is emitted during the outburst, and if the high-energy particles were generated in this way, the continuous activity would not be explained. There is evidence, however, suggesting that condensed supernova remnants are present and that these probably maintain the overall activity in the Crab. Arguments leading to this conclusion are outlined. It is suggested that in a supernova explosion a rotating object with mass greater than the critical mass for a neutron configuration breaks up into many smaller objects. Some fragments may be thrown out of the nebula at high speeds, and there might thus be an extensive population of such objects in and around the Galaxy, and the energy residing in these fragments, released in the form of high-energy particles, may maintain the Crab activity. (UK)

**18294** THE SPECTRUM OF NOVA DELPHINI 1967 SINCE OCTOBER 1967. APPEARANCE OF NEBULAR RAYS. Fehrenbach, Charles; Andrillat, Yvette; Bloch, Marie; Houziaux, Leo (Observatoire de Haute Provence, Basses-Alpes, France). Compt. Rend., Ser. A, B, 267: 1177-80(Nov. 18, 1968). (In French).

The evolution of Nova Delphini 1967, described up to October 1967, remained constant until December 6, 1967. On December 12, 1967, however, at the brilliancy maximum of the star, the spectrum was much changed: the emission rays were much weakened, even those of hydrogen, but fine sharp absorption rays, displaced about $-350$ km sec$^{-1}$, appeared. Beginning on December 15 there was a brilliance regrowth of the emissions of H, Fe II, and Ca II, much larger than before December. On June 7, after interruption of the observations for 25 days, the spectrum appeared simplified with the disappearance of numerous emission rays and the weakening of absorption rays. The spectrum obtained August 3 had a very different aspect from the previous observation of July 20, the nova had attained a nebular state. The permitted and forbidden rays observed are tabulated. A tentative interpretation is given of the structure of the emission rays. (J.S.R.)

**18295** MICROTURBULENCE IN 3 CENTAURI A. Hardorp, Johannes (Hamburger Sternwarte, Hamburg. Inst. of Theoretical Astronomy, Cambridge, Eng.); Bidelman, William P.; Proelss, Joachim. Z. Astrophys., 69: 429-34(1968).

Line profiles from a high-resolution spectrogram show that the microturbulent velocity is lower than 2 km/sec. Metal abundances and observations of the continuous radiation are rediscussed. (auth)

**18296** THE WOLF-RAYET STARS AND MASS LOSS. Underhill, Anne B. (Univ. of Utrecht). Astrophys. Space Sci., 3: 109-16(Jan. 1969).

Wolf–Rayet stars are defined, a summary is given of the properties of Wolf–Rayet stars, and a qualitative model of a Wolf–Rayet star is sketched. It is incontrovertible that Wolf–Rayet stars are losing mass, a typical rate of mass loss being near $10^{-5}$ $M_\odot$ per year. The outward directed velocity of the expanding shell has been estimated for 10 stars. The largest value found is 2500 km/sec; most values lie between 1000 and 1500 km/sec. Two outstanding problems are to understand how the observed high velocities are generated and to demonstrate quantitatively the effect of these velocities on the observed spectrum. Five questions raised by the fact that mass loss is observed to take place from Wolf–Rayet stars are discussed briefly. (auth)

**18297** ROCKET OBSERVATIONS OF MASS LOSS FROM HOT STARS. Morton, Donald C. (Princeton Univ., N. J.). Astrophys. Space Sci., 3: 117-22(Jan. 1969).

Rocket observations have shown that the far-ultraviolet resonance lines have P-Cygni profiles in the spectra of many hot stars, including OF and Wolf-Rayet stars and OB supergiants.

Velocity shifts as high as $-3000$ km sec$^{-1}$ have been measured for the short-wavelength edges of some of the lines. Estimates of the rates of mass loss range from $10^{-8}$ to $10^{-6}$ $M_\odot$ year$^{-1}$. (auth)

**18298** POSSIBILITY OF MASS LOSS IN THE RED-GIANT STAGE FROM H–R DIAGRAMS OF GALACTIC CLUSTERS. Barbaro, G.; Dallaporta, N.; Fabris, G. (Univ., Padua). Astrophys. Space Sci., 3: 123-38(Jan. 1969).

A statistical research on evolved stars beyond hydrogen exhaustion was performed by comparing the H–R diagrams of about 60 open clusters with a set of isochronous curves without mass loss derived from Iben's evolutionary tracks and time scales for Population I stars. Interpreting the difference in magnitude between the theoretical positions thus calculated and the observed ones as due to mass loss, when negative, the results indicate that this loss may be conspicuous only for very massive and red stars. However, a comparison with an analogous work of Lindoff reveals that the uncertainties connected with the bolometric and color corrections may invalidate by a large amount the conclusions which might be drawn from such research. (auth)

**18299** VARIABILITY OF THE METALLIC-LINE STAR 28 ANDROMEDAE. Nishimura, Shiro (Tokyo Univ.). Astrophys. Space Sci., 3: 77-9(Jan. 1969).

The metallic-line A-type star 28 And was found to be variable both in brightness and radial velocity. The brightness in blue varies by 0.05 mg, and the radial velocity by 5 km/sec with a period of 102 minutes. The minimum light occurs 0.12 P before the maximum radial velocity. The relation of 28 And to $\delta$ Scuti variables is briefly discussed. (auth)

**18300** EVOLUTION OF CLOSE BINARIES AND ORIGIN OF ALGOL-TYPE SYSTEMS. Ziolkowski, J. (Inst. of Astronomy, Warsaw). Astrophys. Space Sci., 3: 14-30(Jan. 1969).

The evolution of close binary systems was followed for ten systems with the initial mass of the primary in the range 1 to 4 $M_\odot$ and with different initial mass ratios and initial separations. A brief discussion of the evolution of the contact component is presented for two separate cases: when the primary reaches its Roche lobe during central hydrogen burning (case A) and after the exhaustion of hydrogen in the center (case B). The models obtained are compared with observed semi-detached systems separately for massive (with total mass greater than 5 $M_\odot$) and low mass (with total mass below 4 $M_\odot$) binaries. It is shown that the contact components of the observed massive binaries are probably burning hydrogen in the core. On the contrary, the majority of contact components of the observed low-mass binaries are burning hydrogen in the shell. The observed distribution of such binaries as a function of different luminosity excesses of contact components seems to indicate that their origin is connected with case A rather than with case B. (auth)

**18301** DYNAMICS OF CLOSE BINARY SYSTEMS WITH MASS EXCHANGE. Hadjidemetriou, John D. (Univ. Thessaloniki, Greece). Astrophys. Space Sci., 3: 31-45(Jan. 1969).

The effects of nonisotropic ejection of mass from either component of a binary system on the orbital elements are studied, for the case of a small initial eccentricity of the relative orbit, when all the ejected mass falls on the other component. The problem is transformed to an equivalent two-body problem with isotropic variation of mass, plus a perturbing force which is a function of the initial conditions of ejection of the particles and their final positions and velocities when they fall on the surface of the other star. The variation of the orbital elements are derived. It is shown that, to first-order terms in the eccentricity, the secular change of the semimajor axis is equal to the one corresponding to the case of zero initial eccentricity. On the contrary, the secular change of the eccentricity is smaller and it depends on the variations of mass ejection due to the finite eccentricity. (auth)

**18302** BEHAVIOR OF THE CEPHEID VARIABLES IN THE COLOR–COLOR DIAGRAM. Nikolov, N.; Kunchev, P. (Univ., Sofia). Astrophys. Space Sci., 3: 46-55(Jan. 1969).

The catalog of the mean light-curves and colors of the Cepheids in the UBV system (Nikolov, 1968) for 240 Cepheids was used to construct the curves which represent plots of their U–B versus B–V color indices. These curves form three groups: linear curves, open curves, and curves possessing a loop. An opinion that the presence of a loop may be a criterion for Population II objects is not confirmed. It is shown that the slope of such curves (corrected for reddening) with respect to the B–V axis increases with the period. The area delimited by the curves on the U–B/B–V diagram remains almost the same up to a period of about 9 to 10 days, whereafter it increases with the period. The possible causes for this behavior of the Cepheids on the color-color diagram, which is connected with the ultraviolet emission of these stars, are discussed. (auth)

**18303** MASS LOSS FROM CORONAE AND ITS EFFECT UPON STELLAR ROTATION. Nariai, Kyoji (Goddard Space Flight Center, Greenbelt, Md.). Astrophys. Space Sci., 3: 150-9(Jan. 1969).

The acoustic energy-generation rate from the convective zone was calculated for various models. Results show that chromosphere and corona can be expected around stars with temperature lower than 8000°K at the main sequence, and lower than 6500°K at log g = 2. When a star is rotating rapidly, mass loss from its corona is large, and can be an effective mechanism of braking the stellar rotation. If this mechanism is effective, one can explain the slow rotation of stars later than F2 to be the result of the loss of the angular momentum through a stellar wind that is effective in their main sequence phase. Stars with mass $M > 1.5$ $M_\odot$ lose mass through a stellar wind during their contraction phase. The mass-loss rate is larger than the solar value because of the larger energy input into the chromosphere–corona system and because of the smaller gravitational potential at the surface. T Tauri stars may be the observational counterparts for such stars. As the duration of contraction phase is very short (less than $10^7$ years), the braking mechanism works only in the presence of a strong magnetic field (Ap) or in the presence of a companion (Am). (auth)

**18304** CORONAE AROUND HELIUM STARS AND X-RAY SOURCES. Nariai, Kyoji (Goddard Space Flight Center, Greenbelt, Md.). Astrophys. Space Sci., 3: 160-2(Jan. 1969).

Calculations of the acoustic energy generation for a helium-rich composition show that the maximum acoustic energy generation is located around 12,000°K at log g = 4 and 15,000°K at log g = 6. The author's suggestion in his last paper that a helium star $\upsilon$ Sgr may have a corona seems to be justified. X rays from a corona around a helium star is strongest when the physical parameters of the star are log g $\sim$ 6 and $T_e \sim$ 15,000°K. But the total energy flux is too small to account for the observed x-ray sources. (auth)

**18305** SPECTROSCOPIC STUDY OF THE ECLIPSING SYSTEM R CANIS MAJORIS. Kitamura, Masatoshi (Tokyo Univ.). Astrophys. Space Sci., 3: 163-74(Jan. 1969).

Variation of the residual intensities of metallic and hydrogen lines of R CMa with phase is presented from measurement of its spectrograms obtained with dispersions of 10.3 and 4.1 Å/mm at the Okayama Astrophysical Observatory. It is found from variation of the residual intensities of these lines, with the exception of the Ca K line, that the duration of the eclipse is longer than expected from the photometric elements. The fractional loss of light of the eclipsed component at mid-eclipse has been derived from the ratio between residual intensities of the lines at mid-minimum and outside eclipse. The value so deduced is found to be larger than expected from the light-curve analysis. The behavior of the residual intensities of the K line around the mid-minimum provides some evidence of emission at the line center. The possible existence of gaseous matter surrounding the components is discussed. (auth)

**18306** EVOLUTION THROUGH MASS EXCHANGE IN CLOSE BINARY SYSTEMS OF TOTAL MASS 2.5 SOLAR MASS. Refsdal, S.; Weigert, A. (Univ. of Nebraska, Lincoln). Astrophys. Space Sci., 3: 175-8(Jan. 1969).

Calculations show that the observed semi-detached binary systems of mass $M_1 + M_2 \approx 2.5$ $M_\odot$ can be explained in terms of a mass exchange which starts after the central hydrogen in the original primary has been exhausted. (auth)

**18307** SOME PROBLEMS CONCERNING GAS FLOWS IN CLOSE BINARY SYSTEMS OF DWARF STARS. Gorbatzky, V. G. (Leningrad Univ.). Astrophys. Space Sci., 3: 179-81(Jan. 1969).

The influence of the stream flowing from the secondary on the disk-like envelope of the main star is briefly considered. It is found that the lifetime of the envelope after the flow ceases must be less than $10^6$ sec. (auth)

**18308** MECHANISM FOR THE PRODUCTION OF PLANETARY NEBULAE. Kutter, G. S. (Univ. of Virginia, Charlottesville); Savedoff, M. P.; Schuerman, D. W. Astrophys. Space Sci., 3: 182-97(Jan. 1969).

$^{12}$C stars in the range 1.04 to 1.55 $M_\odot$ are evolved to simulate the core evolution of the possible precursors of planetary nebulae. The nuclear shell burning in stars above 1.2 $M_\odot$ advances to within about 0.2 $M_\odot$ of the surface, where the intense radiation interacts with the surface matter and causes mass loss. Comparison between theoretical results and observations suggests that this may be a mechanism by which planetary nebulae are formed. (auth)

**18309** PHOTOELECTRIC OBSERVATIONS OF CH CYGNI DURING THE EXPLOSIVE PHASES OF 1967–68. Cester, Bruno (Osservatorio Astronomico, Trieste, Italy). Astrophys. Space Sci., 3: 198-204(Jan. 1969).

Observations made at Trieste in 1967 and 1968 of CH Cygni

reveal a strong variability, particularly in U color. From the observed colors, a suggestion is made about the existence of a hot companion which could be a subdwarf. (auth)

**18310** SPECTROSCOPIC EVIDENCE FOR MASS LOSS FROM CH CYGNI. Faraggiana, R.; Hack, M. (Astronomical Observatory, Trieste, Italy). Astrophys. Space Sci., 3: 205-13(Jan. 1969).

Some high-dispersion spectrograms of CH Cygni taken in epochs at which only the M6 spectrum is visible and after the explosions of June 1967 and July 1968 were studied. The strong negative radial velocities of the Ca II chromospheric absorptions and the turbulent motions broadening the emission lines of H I, He I, Fe II, [Fe II] prove that mass is lost from the star at a rate of the order of $10^{-5}$ solar masses per year. Arguments are given in favor of the hypothesis that CH Cygni is a close binary composed of an M giant and a blue unstable subdwarf. (auth)

**18311** CONTINUOUS SPECTRUM OF TAURUS A AT 1.2-mm WAVELENGTH. Beckman, J. E.; Bastin, J. A.; Clegg, P. E. (Queen Mary Coll., London). Nature (London), 221: 944-5 (Mar. 8, 1969).

Measurement is described of the radiation from the region of the Crab Nebula (Taurus A) in a waveband centred at 1.2 mm (250 GHz) in the far infrared. An InSb detector cooled by liquid He was employed, placed at the cassegrain focus of the 98 inch Newton telescope of the Royal Greenwich Observatory, in conjunction with a rapid-scan unit. Results are shown summarizing the averaged data of 3,000 scans, representing 1 hr of integration time across the source, together with subtracted scans of sky background. Comparative data for Jupiter are also shown. It is indicated that while Jupiter behaves essentially as a point source, the nebula has a finite angular diameter of average value 4 of arc in declination. In order to calculate the relative fluxes from Jupiter and Taurus A circular symmetry was assumed for each object. Neglecting the effect of atmospheric water vapor, a flux ratio Taurus A/Jupiter of 1.6/1 was obtained, or taking account of water vapor the corrected relative intensities were in the ratio 0.84/1. This result may be combined with an estimate of the absolute flux from Jupiter to plot an important point on the continuous spectrum of Taurus A; a flux density of 13,400 flux units (one flux unit = $10^{-26}$ $wm^{-2}Hz^{-1}$) at 250 GHz is found. An assembled spectrum of the source from the work of others and including the foregoing value is shown. Results confirm that there is a large-mm excess in the spectrum of Taurus A. It may be that the relativistic electrons which cause the x-ray and optical synchrotron emission in the knots and filaments of the nebula give rise to sub-mm and mm radiation of a similar nature in the pervading much weaker general magnetic field. (UK)

**18312** ABSOLUTE PROPER MOTIONS AND SPACE VELOCITIES OF 12 OPEN CLUSTERS. de Vegt, Chr.; Gail, H.-P.; Gehlich, U. K. (Hamburger Sterwarte, Hamburg). Z. Astrophys., 69: 330-6(1968).

Using the preliminary AGK3-data, absolute proper motions in the FK4-system were obtained for 12 open clusters. The resulting space velocities show very large W components in the case of NGC457, NGC581, Tr1, and IC1805; these values seem to be improbable, reasoning dynamically. It is concluded that the distances of these clusters are still overestimated. New values for $R = A_V/E_{B-V}$ are discussed for these objects. (auth)

**18313** ON THE SURFACE GRAVITY AND TEMPERATURE OF VEGA. Hardorp, Johannes (Hamburger Sternwarte, Hamburg); Scholz, Michael T. Z. Astrophys., 69: 350-62(1968).

The difficulties in deriving correct parameters of a model atmosphere are discussed by comparing two extreme models for $\alpha$ Lyrae. The recent measurements of the continuum by Hayes are fairly represented by a model with $T_{eff} = 10{,}000°$, $\log g = 3.55$, whereas the ionization equilibria of four elements demand $T_{eff} = 9200°$, $\log g = 4.0$. New photographic profiles of high quality are reported for Hγ and Hδ. No satisfactory agreement between observed and computed profiles can be achieved at the same time for Hβ, Hγ, and Hδ by either model, whichever of the current broadening theories one chooses. (auth)

**18314** ESCAPES AND CAPTURES. Kotsakis, D. (Univ. of Athens). Z. Astrophys., 69: 337-49(1968).

The problem of escapes and (temporary) captures is investigated in the case of the restricted three-body problem with equal masses. In most cases the third body either escapes very fast, after a close approach to one primary, or probably does not escape at all, although the curve of zero velocity is open. In a few cases many successive close approaches do not produce an escape. (auth)

**18315** INTERPRETATION OF SPECTRAL LINE BROADENING BY FOREIGN GASES. Behmenburg, Wolfgang (Univ. Saarlandes, Saarbruecken, Ger.). Z. Astrophys., 69: 368-84(1968). (In German).

Halfwidth, shift, and asymmetry ratio of spectral lines broadened by neutral atoms are calculated on the basis of the Lindholm theory for general pressures, assuming a Lennard–Jones potential for the interaction. The calculations are compared with measurements of pressure and temperature effects of argon and neon on the Cs 8943-Å line. In case of argon there is good agreement, in case of neon considerable deviations are observed. The deviations are discussed considering the basic assumptions of the theory. (auth)

**18316** REFRACTION ANOMALIES: THE MEAN POWER SPECTRUM OF STAR IMAGE MOTION. Hoeg, Erik (Hamburger Sternwarte, Hamburg). Z. Astrophys., 69: 313-25(1968).

A simple formula has been found for the mean error of the mean value of n discrete observations of a stochastic variable with any given power spectrum. According to observations the mean spectrum of image motion in zenith caused by the atmosphere can be described by $P_M(f) = 0.08f^{-0.5}(1 + 2f)^{-1}\ \square''/cps$ for the frequencies $0.000\ 01\ cps \leqq f \leqq 10\ cps$. This spectrum contradicts the assumption found in literature about a maximum near 0.12 cps. The spectrum $P_M(f)$ implies that the average accuracy for a single star with the best PZT's, astrolabes, and transit circles is limited mainly by image motion, which causes a mean error $\sigma_T = 0''.33(T + 0.65)^{-0.25}$ for any integration time $T \geqq 0.2$ sec. (auth)

**18317** FERROMAGNETIC TRANSITION IN SUPERDENSE MATTER AND NEUTRON STARS. Brownell, D. H. Jr.; Callaway, J. (Louisiana State Univ., Baton Rouge). Nuovo Cim., 60B: 169-88(Mar. 11, 1969).

The conditions for dense nuclear matter to undergo a ferromagnetic transition are estimated, and shown to be applicable to neutron stars. The relativistic equation of state for interacting hard-core nucleons at T = 0 is developed, and used in integrating the general-relativistic hydrodynamic-equilibrium equation for the Schwarzschild metric. The calculation yields the boundaries between unmagnetized, partially magnetized, and fully magnetized nuclear matter in the star, and also the total mass and the radius of the star. The latter two quantities, as functions of central density, are in qualitative agreement with other calculations of the equilibrium properties of a star composed of interacting nuclear matter. (auth)

**18318** USE OF BVr PHOTOMETRY TO DERIVE METAL ABUNDANCES IN G8–K2 GIANTS. Mannery, Edward J.; Wallerstein, George; Welch, Gary A. (Univ. of Washington, Seattle. Kitt Peak National Observatory, Tuscon, Ariz.). Astron. J., 73: 548-50(Sept. 1968).

The color difference (B – V) – (V – r) was found to correlate with the iron-to-hydrogen ratio of stars of type G8-K2III. The slope of the correlation is greater for stars with V – r < 0.70 than for the cooler stars. Metal abundances derived from the index (B – V) – (V – r) are uncertain by about factors of 2 and 3 for the hotter and cooler stars, respectively. The application of the system to stars in M67 indicates that M67 stars have 60% more metals than do stars in Hyades–Praesepe. The uncertainties are sufficiently large to permit the composition of M67 to be identified with Hyades–Praesepe. In general, it appears that the index (B – V) – (V – r) may be used as a metal abundance indicator for stars of types G8-K2 and luminosity class near III. (BBB)

**18319** DYNAMICAL EFFECTS OF MASS EXCHANGE IN CLOSE BINARY SYSTEMS. Hadjidemetriou, John D. (Univ. of Thessaloniki, Greece). Astrophys. Space Sci., 3: 330-44(Feb. 1969).

The problem of mass exchange in a close binary system is studied from the point of view of the evolution of the orbital elements. It is assumed that the original orbit is nearly circular and one of the components has expanded and fills the area inside the equipotential surface passing through the inner Lagrangian point $L_1$, losing mass to the other component. The mass is assumed to be ejected along the tangent to the equipotential surface passing through $L_1$ in retrograde orbits. It is proved that the eccentricity remains very small. The semimajor axis increases in almost all cases where the mass is being transferred from the less massive to the more massive component, and decreases when the mass is being transferred from the more massive to the less massive component. It is also shown that if the more massive star evolves first and loses mass to its companion, the process of mass exchange continues automatically until the originally more massive component becomes the less massive one and the binary system remains in an almost static condition for long intervals of time, the less massive component occupying the area inside the equipotential surface passing through $L_1$ and surrounding the star. (auth)

**18320** EVOLUTIONARY STAGES OF VISUAL BINARY COMPONENTS. Giannone, P.; Giannuzzi, M. A. (Osservatorio

Astronomico, Rome). Astrophys. Space Sci., 3: 301-11(Feb. 1969).

In the assumption of a coeval origin of the components of visual binaries, the possible evolutionary stages of the stars forming a system can be studied on the basis of the differences in apparent visual magnitudes and color indices. According to such differences, a subdivision of systems in groups depending on the evolutionary stages of the components was investigated. Some rough limiting estimates of the masses can be attempted. A comparison with observations is given. (auth)

**18321** PHYSICAL CONDITIONS IN THE CONVECTIVE ENVELOPES OF STARS. I. MAIN-SEQUENCE STARS. Castellani, Vittorio (Univ., Rome); Renzini, Alvio. Astrophys. Space Sci., 3: 283-91(Feb. 1969).

The physical conditions in the convective envelopes of Pop-II main-sequence stars are described with some detail. A particular care has been devoted to the effects due to the formation of hydrogen molecules and to the pressure ionization. (auth)

**18322** THE STRUCTURE OF A SHOCK FRONT IN ATOMIC HYDROGEN. IV. STABILITY, DISSIPATION, AND PROPAGATION. Skalafuris, Angelo J. (City Coll., New York). Astrophys. Space Sci., 3: 234-57(Feb. 1969).

The problem of a shock wave propagating in a gravitational field in the presence of pressure and density gradients is examined by attacking the nonlinear equations of fluid flow. The approach is analytical rather than numerical, and the characteristic equations of a fluid in the presence of gravity with radiative dissipation are analyzed. Because the radiation field enters the fluid equations in the form of an integral, radiative dissipation may be considered an inhomogeneity which does not affect the characteristic directions. The fluid equations remain hyperbolic and thus are amenable to solution by the standard techniques of gas analysis. An equation of path for a shock wave is given and the physical conditions which lead to stability or instability are enumerated. It is found that shock waves are generally unstable in most stellar atmospheres unless they are very weak. The form of the instability is that of a spicule deformation similar to that observed in the upper solar chromosphere. (auth)

**18323** THERMODYNAMIC APPROACH TO THE EQUATION OF STATE OF A MAGNETIZED FERMI GAS. Canuto, V. (Goddard Space Flight Center, New York); Chiu, H. Y.; Fassio-Canuto, L. Astrophys. Space Sci., 3: 258-67(Feb. 1969).

The equations of state for a magnetized Fermi gas were rederived by generalizing the physical definition of the pressure. A simplified derivation of the energy eigenvalues of a free electron in a magnetic field are also given, based on the use of simple harmonic oscillators. Physical interpretations of the results are presented. Possible astrophysical applications are also discussed. (auth)

**18324** OSCILLATIONS OF THE ATMOSPHERES OF PULSATING STARS. Takeuti, Mine (Tohoku Univ., Sendai). Astrophys. Space Sci., 3: 219-28(Feb. 1969). (In French).

Nonadiabatic linear oscillations of the stellar atmosphere are studied by deriving the general solution of the equation of the problem. Boundary conditions which were obtained at the stellar surface are confirmed for the pulsation of the cepheid variables. It is shown that the progressive wave coupling with the stellar pulsation is possible in the atmospheres of red supergiants. (auth)

**18325** CURRENT PROBLEMS IN THE THEORY OF LATE-TYPE STARS. Demarque, Pierre (Yale Univ. Observatory, New Haven). Astron. J., 73: 669-76(Oct. 1968).

Present uncertainties in the position of the main sequence for Population I and Population II stars, and in the ages and chemical composition of old galactic clusters and globular clusters are discussed in terms of galactic evolution and current views in cosmology. There is evidence, both observational and theoretical, that the old galactic clusters NGC 188 and M67 are richer in heavy element content than the Sun. In particular, in order to explain the observed gap above the main sequence in NGC 188, one must set Z = 0.06 to 0.07. The age of the cluster is then about $6 \times 10^9$ yr. The presence of stars with such a high Z could raise questions on the calibration of the absolute magnitudes of Population I variable stars. There is one evidence from old stars in the Galaxy that the helium content is nearly uniform in a first approximation, with Y = 0.25 to 0.30 as a minimum, seemingly in agreement with primordial fireball predictions. It seems then possible to date the oldest globular star clusters within the presently accepted estimate of the Hubble time, with ages of the order 10 billion yr. Horizontal branch stars would then have started on the main sequence with masses near 0.8 $\underline{M}$. There is, however, an indication that, in a second approximation, the helium abundance may differ from cluster to cluster, the range in Y being less than 10%. The outer clusters (such as NGC 7006) would then represent the primordial helium abundance, suggesting that some regions of the Galaxy have gone through a process of helium enrichment. This helium might have been produced in massive stars or perhaps in some kind of supermassive object or objects. (BBB)

## *Quasi-Stellar, Radio, and X-Ray Sources*

**18326** TWO NEW PULSATING RADIO SOURCES. Taylor, J. H. (Harvard Coll. Observatory, Cambridge, Mass.); Huguenin, G. R. Nature (London), 221: 816-17(Mar. 1, 1969).

Two new pulsars have been discovered and their parameters measured. These are designated PSR 0904 + 77 and PSR 2218 + 47. (auth) (UK)

**18327** RADIOELECTRIC EMISSION FROM CASSIOPEIA A. Surdin, Maurice (Faculte des Sciences de Bordeaux, Talence, France). Compt. Rend., Ser. A, B, 267: 1455-8(Dec. 23, 1968). (In French).

The results of using the mechanism of fluctuating magnetic fields from ionized clouds with a variation as a function of radio-emission time from Cassiopeia A are in good agreement with observations. (tr-auth)

**18328** POLARIZATION OF OH RADIO WAVES. Varshalovich, D. A. (Ioffe Inst. of Physics and Tech., Leningrad). Zh. Eksp. Teor. Fiz., 56: 614-18(Feb. 1969). (In Russian).

Formulas are derived for the polarization parameters and amplification and attenuation coefficients for the hydroxyl resonance radio waves of 1612, 1665, 1667, and 1720 Mc traversing a medium containing OH radicals with arbitrarily oriented spins under the condition that $\Delta\nu_{Dop} \gg \Delta\nu_{Zeem} \gg \gamma$. (auth)

**18329** RADIO EMISSION FROM MAGNETIC NEUTRON STARS. A POSSIBLE MODEL FOR PULSARS. Chiu, Hong-yee; Canuto, Vittorio (Goddard Inst. for Space Studies, New York). Phys. Rev. Lett., 22: 415-19(Mar. 3, 1969).

It is shown that radio emission from a neutron star with a magnetic field of $10^9$ G or more can account for the radio emission of pulsars. It is suggested that pulsars also emit two bands, one in the uv or optical, and the other in the infrared in the decamicron wavelength range. (auth)

**18330** OPTICAL VARIATIONS OF 3C 454.3. Lil, P. K.; Hunter, J. H. (Yale Univ., New Haven). Nature (London), 221: 755-7(Feb. 22, 1969).

Reference is made to a photographic study of selected quasars at Yale and elsewhere made since 1966. Measurements were made with an iris photometer, and a composite light curve of 3C 454.3 derived from the Yale measurements and earlier data, is shown. The observational evidence suggests that this object may be periodic, with a period of ~340 days. A plot of magnitude versus phase for this period is also shown. If the object does have a fundamental period of ~340 days the occurrence of another light maximum is predicted on about July 4, 1969, and the outburst should last about 20 days. B magnitude variations were also observed for a number of other quasars. (UK)

**18331** THE CYGNUS X REGION. IV. NOTE ON THE RADIO SOURCE W 63. Wendker, H. (Univ. of Illinois, Urbana). Z. Astrophys., 69: 392-8(1968).

New observations are presented which show that the radio source W 63 has a shell-type structure. The spectral index of the integrated flux density is about −0.25. As no optical identification can be made several possible interpretations of the radio data are discussed. It is concluded that W 63 is most likely a galactic supernova remnant. (auth)

**18332** INTERPRETATION OF QUASAR RED SHIFTS. Piper, D. E. Nature (London), 221: 919-21(Mar. 8, 1969).

A procedure is proposed for analyzing quasar redshifts, assuming the redshifts are due to a combination of both cosmological and gravitational factors. (auth) (UK)

**18333** FURTHER MICROWAVE EMISSION LINES AND CLOUDS OF AMMONIA IN OUR GALAXY. Cheung, A. C.; Rank, D. M.; Townes, C. H.; Welch, W. J. (Univ. of California, Berkeley). Nature (London), 221: 917-19(Mar. 8, 1969).

Further $NH_3$ emission has been found in the Sagittarius region, giving clues to the conditions in dust clouds. (auth) (UK)

**18334** COSMOLOGICAL IMPLICATIONS OF THE DIFFUSE X-RAY BACKGROUND. Felten, James E.; Rees, Martin J. (Cambridge Univ., Eng.). Nature (London), 221: 924-6(Mar. 8, 1969).

Isotropic cosmic x rays in the 1 keV to 1 MeV range may be due to the Compton–blackbody process acting in remote radio galaxies or quasars. The break in the x-ray spectrum then poses a stringent condition on theories of radio-source evolution and distribution. (auth) (UK)

**18335** DISCRETE SOURCE INTERPRETATION OF RECENT HIGH ENERGY COSMIC-RAY MEASUREMENTS. Ogelman, H. (Goddard Space Flight Center, Greenbelt, Md.). Nature (London), 221: 753-4(Feb. 22, 1969).

It is stated that recent data from the high-energy gamma-ray detector on OSO-3 comprise the first convincing measurements of cosmic gamma rays of ~100 MeV. The angular distribution indicates that a large fraction of this flux originates in the galactic disk. A possible interpretation is in terms of secondary gamma rays produced by the interactions of cosmic rays with the ambient interstellar gas, but fluxes predicted from this mechanism are low by more than an order of magnitude. An alternative explanation is explored in which most of the flux is caused by unresolved discrete sources. By considering the distribution of x-ray data in the galactic plane in conjunction with the angular response function of the OSO-3 detector, the galactic plane profile can be predicted and checked against observations. From the total measured fluxes in the x-ray and gamma-ray region the spectral index can be predicted and compared with measurements of the power law index in the soft and hard x-ray region, and the implied gamma-ray fluxes can be compared with balloon experiments in the 100 MeV region. The main evidence in favor of the discrete source model is the galactic distribution of the events. The implied gamma-ray fluxes above 100 MeV are $\sim 5 \times 10^{-5}$ photons/cm$^2$/s, comparable with the experimental upper limits of $10^{-4}$ to $3 \times 10^{-5}$. It is concluded that although it is naive to expect all the x-ray sources to behave identically, the assumption that on the average they have a –2.0 differential index up to the 100 MeV region would enable an explanation of the observed gamma-ray flux, while still retaining the accepted values of galactic cosmic-ray flux and ambient gas distribution. The gamma flux levels predicted for these sources are close to the sensitivity threshold of present balloon detectors and positive measurements should be possible in the near future. (UK)

**18336** CLASSIFICATION OF THE QUASAR HYPOTHESES. Kalinkov, Marin; Polikarov, Azari. Izv. Sekts. Astron., Bulg. Akad. Nauk, 2: 157-66(1967). (In Bulgarian).

Assuming luminosity, variability, type of object, energetics, multiplicity, and difference in mass as basic parameters, quasar hypotheses are classified. The 9900 cases are obtained in the general solution. Of those 2280 do not exhibit internal contradictions and are not contrary to the fundamental physical laws. About 300 possible quasar hypotheses have so far been worked out. (Abstr. of Bulg. Sci. Lit.)

**18337** AN ELECTRON TEMPERATURE DISTRIBUTION DERIVED FROM OPTICAL AND RADIO MEASUREMENTS OF HII REGIONS. Mansfield, Victor (Cornell Univ., Ithaca, N. Y.). Astrophys. Space Sci., 3: 292-300(Feb. 1969).

Radio measurements of the electron temperature of H II regions are obtained from the ratio of the brightness temperature of a hydrogen recombination line to that of the adjacent continuum, while optical measurements are obtained from the ratio of [O III] forbidden-line intensities. The radio and optical measurements made under the assumption of an isothermal H II region, $T_R$ and $T_{opt}$ respectively, are combined to derive a temperature distribution for an entire nebula. A spherical H II region in local thermodynamic equilibrium with constant density which is optically thin in both the line and the continuum is used as a model. Assuming linear temperature gradients, with $T_R$ = 6,000 K and $T_{opt}$ = 10,000 K, it is found that T = 12,000 K (1 to 0.74 r/R), where r is the distance from the center and R is the radius of the nebula. (auth)

**18338** OBSERVATIONS OF INTENSE RADIO SOURCES WITH A 1'.5 FAN BEAM. Legg, T. H. (National Research Council, Ottawa); Bell, M. B.; Bignell, R. C. Astron. J., 73: 749-55(Nov. 1968).

From June 1966 to January 1968, seven of the most intense discrete radio sources and the Moon were observed repeatedly with a new antenna array having a 1'.5 fan beam. The right ascension and east–west structure were determined at 10.7 cm. The sources observed were Tau A, the Orion Nebula, 3C273, CygA, CasA, and the Omega Nebula. Observations of the Moon were made concurrently in an attempt to reduce systematic error by relating the lunar transit to the transit of the sources. Standard errors in right ascensions range from 0$^s$.16 to 0$^s$.58 and agreement as good or better than the standard error is found with the results of Fomalont (1968) at 21 cm, suggesting that there is no strong dependence of position upon wavelength. Some structural features are resolved for all sources except 3C273: the main sources in the Orion and Omega nebulas apparently remain asymmetrical when the secondary sources are accounted for; the peak emission from VirA is more closely associated with the nucleus than the jet, with the halo component contributing ~28% of the total flux; and the third source in CygA contributes an estimated 10% of the total flux. (BBB)

**18339** GLIMPSING THE HIDDEN X-RAY UNIVERSE. Chubb, T. A.; Friedman, H. (Naval Research Lab., Washington, D. C.). Astronaut. Aeronaut., 7: 50-65(Mar. 1969).

X-ray astronomy and some interpretations of recent findings are reviewed. Some 40 discrete sources have thus far been detected, all but the few x-ray galaxies lying close to the plane of the Milky Way. Some have been identified with supernova remnants, others with starlike objects. The fluxes observed by rocket experiments have ranged from about $5 \times 10^{-7}$ erg/cm$^2$/sec for the brightest source, Sco XR-1, to about $2 \times 10^{-10}$ erg/cm$^2$/sec for the weakest. Of the sources themselves, one of the strongest in the galaxy is the Crab Nebula, the remnant of a supernova explosion seen by Oriental astronomers in 1054 AD. From ir to x rays, the whole spectrum follows a power law for synchrotron radiation, suggesting the x rays are synchrotron also, but attempts to observe polarization have thus far not been sufficiently sensitive. The radiating object may be a neutron star remnant of the supernova, resulting from the collapse of a highly evolved stellar core. Theoretical models for neutron stars require moments of inertia between $10^{44}$ and $10^{45}$ g-cm$^2$; the release of rotational energy must fall between $10^{38}$ and $10^{39}$ erg/sec. These numbers fit the entire energy budget of the Crab Nebula remarkably well. About $10^{37}$ erg/sec is used in radiating x rays and about $10^{38}$ erg/sec in accelerating relativistic particles and creating magnetic fields in the Nebula. Only a few of the most powerful radio galaxies exhibit strong x-ray emission. X-ray galaxies may be more abundant among galaxies of the Seyfert type, whose intense activity in their extremely bright nuclei may be very young explosions. (BBB)

**18340** GALACTIC RADIO EMISSION AT 610.5 MHz. II. THE REGION BETWEEN GALACTIC LONGITUDES 55$^0$ AND 64$^0$. Wendker, H. (Univ. of Illinois, Urbana). Astron. J., 73: 644-8(Sept. 1968).

A section of the galactic plane between galactic longitudes 55° and 64° was observed at 610.5 MHz with a resolution of 16 min of arc. A contour map is presented for this region. Twenty-two discrete sources were resolved from the galactic background radiation. Nine of these are point sources. The other 13 sources are extended and 3 of them are newly identified with faint HII regions. By using the observed maximum brightness temperature at 610.5 MHz and by assuming an electron temperature $T_e$, it was possible to calculate the emission measure for an optically thin HII region. Emission measures of 1100, 1550, and 1000 cm$^{-6}$ pc were derived for G61.2 – 0.2, G61.7 + 0.2, and G63.3 + 0.5, respectively. This, however, is only correct if the diameter of the source is equal to or greater than the size of the beam. This condition seems to be fulfilled for G61.2 – 0.2 and G61.7 + 0.2. For a smaller source a correction factor has to be applied which is equal to the ratio of the beam solid angle to the source solid angle. The dia of G63.3 + 0.5 is much smaller than the beam dia. From the optical dia a corrected emission measure of nearly 8000 cm$^{-6}$ pc was derived. (BBB)

**18341** OBSERVATIONS OF RADIO SOURCES AT 10.03 MHz. Bridle, A. H. (Queen's Univ., Kingston, Can.); Purton, C. R. Astron. J., 73: 717-26(Oct. 1968).

Studies of discrete radio sources at frequencies less than 20 MHz are severely hindered by ionospheric absorption and scintillation, so that few sources had been observed at such frequencies until the recent period of minimal solar activity. Typical values of the total electron content of the ionosphere were particularly low during this period, and observations could be made at frequencies that are unsuitable for radio astronomy during most of the solar cycle. Results of observations of discrete sources made between October 1965 and March 1966 with the 10.03 MHz telescope at the Dominion Radio Astrophysical Observatory, Penticton, Canada, are reported. Flux densities are derived for 124 radio sources which were observed. The procedure used to correct the observations for ionospheric effects, and the method of calibration of the flux density scale are described. The deflection of the output record at the maximum of the fitted response was corrected for ionospheric absorption and for variation in the receiver sensitivity. The theoretical value of the antenna gain, allowing for refraction, was then used to obtain the calibration noise power to which the source would be equivalent if observed at the zenith and in the absence of the ionosphere. The flux density of the source was then derived by comparing this noise power with the corresponding value obtained from the observations of Cas A. The observational results are given in tables. One table lists flux densities for 124 sources, and another table lists upper limits to the flux densities

of 8 sources that were not detected on several occasions when observations of sources in neighboring areas of sky showed that observing conditions were favorable. (BBB)

## Solar Phenomena

*Refer also to abstracts 17781, 17845, 18458, and 18466.*

**18342** (AD-674060) EQUILIBRIUM STRUCTURE OF A SHOCK-HEATED CORONA. Report No. Scientific-4. Kopp, Roger A. (Harvard Coll. Observatory, Cambridge, Mass.). June 1968. Contract AF19(628)-3877. 308p. (AFCRL-68-0312). CFSTI.

Thesis.

A theory of shock propagation in a spherical atmosphere is presented, which incorporates both the damping of a shock by its wake and changes of shock strength caused by nonuniform properties and hydrodynamic motions in the preshock gas. This theory is applied in conjunction with the time-averaged conservation equations for radial flow to determine the structure of a stellar corona whose quasi-steady dynamical state is maintained by a balance between shock-wave dissipation, thermal conduction, radiation, and coronal expansion. For the Sun's corona, it is shown that a single theoretical model is capable of simultaneously representing observations of coronal electron densities, properties of the solar wind in interplanetary space, and intensities of the solar ultraviolet emission lines. The gross energy balance of an expanding shock-heated corona is discussed, with particular reference to the numerical model which best represents the quietday Sun. The processes of radiation, conduction, mechanical dissipation, and convective outflow are each examined as to their relative importance in determining the equilibrium structure of different atmospheric layers. (auth) (USGRDR)

**18343** (AD-674527) LARGE-SCALE CONFIGURATION OF THE CORONAL AND INTERPLANETARY MAGNETIC FIELD. Technical Report. Schatten, Kenneth H. (California Univ., Berkeley. Space Sciences Lab.). Aug. 15, 1968. Contract Nonr-3656(26). 125p. CFSTI.

A physical model that is consistent with many of the properties observed in the corona and in interplanetary space was developed. The model allows the large-scale magnetic-field configuration above the photosphere to be computed from photospheric magnetic field observations using Green's function solution to Maxwell's equations. Sources for the magnetic field are related to the observed photospheric field and to the field computed at a "source" surface about 0.6 solar radii above the photosphere. The model is able to explain the shape of rays and streamers in the inner corona. (auth) (USGRDR)

**18344** (N-68-31352) ANALYSIS OF POLAR CAP ABSORPTION EVENT. 5. RF PROFILES, ACTIVE SOLAR REGIONS AND ASSOCIATED PHENOMENA, REQUIREMENTS FOR A PROTON WARNING SYSTEM. Jonah, Fred C. (LTV Aerospace Corp., Dallas, Tex. Missiles and Space Div.). June 13, 1968. Contract NAS9-7134. 99p. (NASA-CR-92210). CFSTI.

Data detailed analyses, and interpretations of related solar flare and terrestrial phenomena are presented. Solar flare patrol films from two solar observatories were used to compare multipeak rf emissions with possible multimaxima flares. Visual analysis of films did not produce desired accuracy, although the theory that brightness of flares are associated with multipeak or complex rf emissions was strengthened. The rf time histories were evaluated and classified, and correlated with Hα flares. This showed that if rf emissions with total integrated energy greater than 10 – 17 joules $(m^2\ c/s)^{-1}$ were not followed by a known polar cap absorption (PCA) event, the flare had a slow and gradual rise to maximum intensity. A preliminary analysis of rf emission and Hα flare data from the 20th solar cycle is included. Investigation of flare position with respect to sunspot umbra and flares from sunspots with a δ configuration failed to yield any new statistical evidence concerning their importance to flare–PCA correlation. A bibliography is listed. The rf profiles with PCA and flare maxima are included. (STAR)

**18345** ELECTROSTATIC CHARGE OF INTERPLANETARY GRAINS. Wyatt, Stanley P. (Univ. of Illinois, Urbana). Planet. Space Sci., 17: 155-71(Feb. 1969).

The equilibrium potential of an interplanetary grain is governed essentially by the balance between the photoelectric ejection of grain electrons by solar quanta and the capture of solar-wind electrons by the grain. When the photoelectric effect of the actual euv and x-ray radiation of the Sun are accounted for, the equilibrium potential of a metallic grain during years of a quiet Sun is found to range from about +7 to +18 V, depending on whether the instantaneous flux of the solar wind is near its maximum or its minimum. A working typical value is found to be +12 V, larger by a factor of two or three than other recent estimates. It is estimated that during the peak of the solar cycle the enhanced euv solar radiation may result in grain potentials up to +30 V on occasions when the solar-wind flux is low. As is well known, one of the consequences of the finite electrostatic charge is that the solar wind exerts a Coulombic drag force on an orbiting interplanetary grain, which adds to other perturbative forces to reduce by a factor of about 1.5 the time taken for a grain to spiral inward toward the Sun until it is lost to the zodiacal cloud. (auth) (UK)

**18346** OBSERVATIONS OF FINE STRUCTURE IN THE INTERPLANETARY MEDIUM. Dennison, P. A. (Univ. of Adelaide). Planet. Space Sci., 17: 189-95(Feb. 1969).

Observations of the interplanetary scintillation of radio sources using spaced receivers enable the size and motion of plasma irregularities in the solar wind to be studied. It had been noted previously that the scale of these irregularities is of the order of the ion gyro-radius in the medium, and it is shown that the scale increases with distance from the Sun. (auth) (UK)

**18347** SUPERGRANULES AND THE HYDROGEN CONVECTION ZONE. Simon, G. W.; Weiss, N. O. (Max-Planck-Institut fuer Physik und Astrophysik, Munich). Z. Astrophys., 69: 435-50 (1968).

Solar granules and supergranules are characterized by two different-length scales. Orthodox mixing-length theory cannot account for the preferred diameter of 30,000 km observed in supergranules. However, convective heat transport can be more efficient if the motion extends over several scale heights. The physics of convection in a polytropic atmosphere is discussed, and the results are used to construct a model of convection in the Sun. This model explains the generation of both photospheric granules and supergranules and also suggests the existence of giant cells formed near the base of the convection zone. (auth)

**18348** TRANSITION PROBABILITIES IN np AND $np^5$ CONFIGURATIONS. Warner, Brian (Univ. of Texas, Austin). Z. Astrophys., 69: 399-40(1968).

Transition probabilities were calculated for the magnetic dipole and electric quadrupole components of the $^1P - ^3P$ transitions in np and $np^5$ configurations (n = 2, 3, 4, 5, 6). The isoelectronic sequences were extrapolated to cover the regions of astrophysical interest. Quadrupole radial integrals were calculated from scaled Thomas–Fermi wavefunctions. (auth)

**18349** SOLAR-WIND MODEL INCLUDING THE EFFECTS OF ROTATION, MAGNETIC FIELDS, AND ANISOTROPIC HEAT CONDUCTION. Grzedzielski, S. (Univ., Warsaw). Astrophys. Space Sci., 3: 139-49(Jan. 1969).

A time-independent solar-wind model is considered in the case of spherical symmetry and of radial magnetic field at the Sun's surface. The energy equation includes besides the usual terms also the heat conduction and magnetic-energy convection (Poynting vector) terms. The dependence of the thermal conductivity on the magnetic field is taken into account. Numerical integrations of the basic equations were performed under the following assumptions: (i) close to the Sun the magnetic field is the dominant azimuthal term and solid-body rotation is enforced; (ii) beyond the Alfvénic point the terms quadratic in B are neglected. The model leads to azimuthal velocity at Earth between 0.6 and 2.7 km/sec, to radial velocity at Earth between 350 and 500 km/sec, and to angular momentum loss of $5 \times 10^{18}$ $cm^2$/sec per unit mass of gas leaving the solar equator. The dependence of the solutions on the reduction of the effective thermal conductivity caused by the microstructures in the solar wind suggests that the conditions at Earth may be largely determined by a transition region in the solar wind, in which the conduction regime changes into an almost adiabatic flow. (auth)

**18350** TYPE-III SOLAR RADIO NOISE BURSTS AT HECTOMETER WAVELENGTHS. Hartz, T. R. (Defence Research Telecommunications Establishment, Ottawa). Planet. Space Sci., 17: 267-87(Feb. 1969).

A study was made of type-III solar radio noise bursts that appear in the recordings of the swept-frequency receivers in Alouette I and II. These bursts extend down in frequency to substantially less than 1 MHz and, in general, have characteristics that are quite similar to those observed at decametric wavelengths except that their duration is increased at the lower frequencies. The electron temperatures in the corona, where the bursts originate, were deduced from their decay rates, and these are shown to decrease much more rapidly with distance from the Sun than expected for the solar wind. These findings, together with the observed frequency drift rates of the bursts, lead to an electron density model for the coronal ir-

regularities extending into the interplanetary regions whose values exceed the solar wind densities by about an order of magnitude. The average source drift velocities are found to be about 0.35c, in substantial agreement with results obtained at metric and decametric wavelengths. These results are discussed with particular reference to the coronal streamers out to solar distances of about ¼ of an Astronomical Unit, and to the probable noise generation processes for the type-III bursts. (auth)(UK)

**18351** LONG-WAVELENGTH SATELLITES TO THE He-LIKE ION RESONANCES IN THE LABORATORY AND IN THE SUN. Gabriel, A. H.; Jordan, C. (United Kingdom Atomic Energy Authority, Abingdon, Eng.). Nature (London), 221: 947-9(Mar. 8, 1969).

Reference is made to satellite lines situated on the long-wavelength side of the He-like resonance lines in laboratory plasmas, and classified as transitions in highly excited Li-like ions; and to intense features in the solar x-ray spectrum, of similar appearance but of different origin, and classified as the forbidden $1s^2\ {}^1S_0 - 1s\ 2s\ {}^3S$, line of the He-like ion. Such satellites have been reported from a number of laboratory plasmas, including sparks, high temperature pinches, and laser-produced plasmas. A detailed classification is derived for the laboratory satellites on the basis of a comparison between calculated and observed wavelengths along the isoelectronic sequence from C IV to Ar XI. A complete set of calculations for energy levels was carried out using the Charlotte Froese Hartree–Fock programme with configuration mixing. Calculated values are also given for the He-like intercombination line and compared with observed values. The satellites fall into three groups. The upper group lies around the intercombination line and, although observed, is difficult to measure. The lower group comprises quartet lines and, as these are close together, their individual assignment is uncertain. The centre group is the most intense and is made up of three lines, and assignments for these are possible. Three possible collision mechanisms are considered for production of the excited levels: (a) inner shell ionization of a Be-like ion; (b) inner shell excitation of a Li-like ion; and (c) dielectronic recombination of a He-like ion. For a low density theta pinch mechanism (c) was confirmed. The observed satellites, however, are more intense over an order of magnitude relative to the He-like line than can be understood from present dielectronic recombination theory. At higher densities it is possible that mechanism (a) or (b) may be important. A critical comparison was made of the solar lines with the laboratory satellite lines. In the solar spectrum a line similar to that in oxygen at 22.09 Å appears alongside each member of the isoelectronic sequence. The intensity in all cases is nearly as high as that of the resonance line, and the position of this solar line is significantly different from that of any of the laboratory lines. It is proposed that the solar lines are formed by single photon emission from the $1s\ 2s\ {}^3S$ level. The single photon emission could be magnetic dipole radiation. (UK)

**18352** AUTOCORRELATION OF THE SUNSPOT NUMBERS. Gabrovski, Ivan; Gadzokov, Vasil; Kalinkov, Marin. Izv. Sekts. Astron., Bulg. Akad. Nauk, 2: 139-49(1967).

Three autocorrelation functions of Wolf numbers are calculated. The first is for synodic Wolf numbers from 65 rot to 1488 rot; the second for the monthly Wolf numbers in the time interval January 1849–December 1964; and the third for the yearly Wolf numbers from 1700 to 1964. These autocorrelation functions are graphically represented. The duration of the 11-year cycle is determined: 10.47 and 10.33 years. The duration of a secular cycle of the sunspot activity is also determined—169.0 ± 0.5 years. The autocorrelation functions show that the existence of 11-year cycles with double maxima should be renounced. (Abstr. of Bulg. Sci. Lit.)

**18353** OUTSTANDING SOLAR RADIO BURST AT 4.2 mm. Croom, D. L.; Powell, R. J. (Radio and Space Research Station, Slough, Eng.). Nature (London), 221: 945-7(Mar. 8, 1969).

Observation is reported of a major solar radio burst at 4.2 mm (71 GHz) and 16 mm (19 GHz). This burst was associated with a class-2B flare on July 6, 1968, and may be the largest ever recorded at mm wavelengths and one of the largest at any wavelength. At the most commonly used solar-monitoring wavelength in the microwave band (10.7 cm) the burst, however, was only of moderate intensity. Details of the burst are tabulated and shown graphically. The outstanding nature of the 4.2-mm burst is shown by the fact that it is the only clearly identified burst observed at this wavelength at Slough since observations commenced in July 1967. The 16 mm event was also very unusual. The spectrum appears to be a good example of the U-type which it has been suggested is associated with polar cap absorption, and hence with proton flares. Preliminary data from space probes Pioneer 6 and 7 also indicate considerable enhancements in proton counting rates. The flare also produced a considerable increase in x rays. Spectrographic records at metric and decametric wavelengths showed the event to have been a typical Type-IV burst. The event was preceded by a rare type of burst at 10.7 cm. ("impulsive outburst"). (UK)

**18354** MERIDIONAL COMPONENT OF THE INTERPLANETARY MAGNETIC FIELD. Bhatia, V. B. Z. Astrophys., 69: 326-9(1968).

An attempt is made to derive the shape of the meridional component of the interplanetary magnetic field. Some properties of this field are discussed. (auth)

**18355** BOL'SHIE RADIOVSPLESKI SOLNTSA. (Great Radiobursts of the Sun). Tsimakhovich, N. P. Riga, Izdatel'stvo Zinatne, 1968. 130p.

The monograph consists of five chapters, the first of which discusses general questions of solar radiobursts and correlation between observational data obtained at different observatories. Longitudinal asymmetry—higher level of solar radioflux as measured at observatories situated at the West coast of the Pacific Ocean is described. The second chapter contains a classification of radiobursts. A four-frequency classification is introduced for conversion of monochromatic data to spectral types. The third chapter is devoted to an analysis of spectral properties of geoeffective radiobursts based upon four-frequency characteristics. The possibility of determination of solar-cosmic-ray chemical composition from four-frequency spectra of radiobursts is considered. In the fourth chapter, the great solar radiobursts monochromatically observed at Soviet observatories, including data of the global radio observatory network are studied. A catalog of 150 radiobursts is given. Similarity of morphological patterns of bursts originating from the same center of activity within several months' interval was found. The fifth chapter contains recommendations on structure of solar radiobursts and on correlation of observations. 114 references. (tr-auth)

**18356** APOLLO SOLAR EXPERIMENTS: PAVING THE WAY FOR ADVANCED SPACE OBSERVATORIES. Winter, Thomas C. Jr. (E. O. Hulburt Center for Space Research, Washington, D. C.). Astronaut. Aeronaut., 7: 65-7(Mar. 1969).

Instrumentation to be used in Apollo Telescope Mount (ATM) experiments to study solar extreme uv (euv) and x-ray spectra is described. The 6 ATM experiments will make observations of the Sun with greater spatial resolution and over a much longer time than can be done with rockets. Five of the instruments will operate in the euv and x-ray regions, portions of the spectrum that cannot be observed below the terrestrial atmosphere (opaque to radiation below 3000 Å). ATM will employ a spectroheliograph designed to record on photographic film the images of the solar disk and corona in the discrete emission lines in two separate wavebands in the euv between 150 and 625 Å. The emissions in this region are of fundamental importance. Two are the resonance lines of neutral (584 Å) and singly ionized He (304 Å). Several emissions (284, 335, and 361 Å), from highly ionized Fe (Fe XV and XVI), appear only in active regions. Other emissions, such as Mg IX at 368 Å and O V at 630 Å, show a strong limb brightening. Typical of the information contained in this spectral region, these emissions studied intently should provide a better understanding of the structure of the solar atmosphere and the processes that shape it. The spectroheliograph will also observe the patterns of the flare, in the chromosphere and lower corona. How this instrument represents an improvement over smaller spectroheliographs flown during the past 10 yr is discussed. The scientific data from the ATM program should generate a major advance in the quality and diagnostics of solar observations and should pave the way for advanced space observatories to explore beyond the solar system into galactic and extragalactic space. (BBB)

## Galaxies

*Refer also to abstract 18457.*

**18357** SIX NEW STELLAR ACCUMULATIONS (TERZAN 3-8) IN THE REGION OF THE CENTER OF THE MILKY WAY AND THE CONSTELLATIONS OF THE SCORPION AND SAGITTARIUS. Terzan, Agop (Carnegie Institution of Washington, D. C. California Inst. of Tech., Pasadena. Observatoire de Lyon. Observatoire de Haute Provence, Basses-Alpes, France). Compt. Rend., Ser. A, B, 267: 1245-8(Nov. 25, 1968). (In French).

Six new stellar clusters were detected on pictures taken with the 48-inch Schmidt telescope of Mount Palomar. Three of them are placed in directions very near the center of the Milky Way and are visible only on red pictures ($\lambda_{av}$ = 6,400 Å). (tr-auth)

**18358** TENTATIVE IDENTIFICATION OF THE DIFFUSE INTERSTELLAR ABSORPTION BANDS AND OF A DIFFUSE INTERSTELLAR DOUBLET LINE. Rudkjoebing, Mogens (Univ. of Aarhus, Denmark). Astrophys. Space Sci., 3: 102-8(Jan. 1969).

The four diffuse interstellar absorption bands at λ4430, λ4760, λ4890, and λ6180 and the two diffuse lines at λ5780 and λ5797 are interpreted as belonging to pre-ionization transitions in $H^-$ and $O^-$, respectively. In both cases the identifications are supported by extrapolations of wave numbers of resonance lines along isoelectronic sequences. In the $H^-$ case the hypothesis as to the origin of the bands is supported by quantum-mechanical results by Herzenberg and Mandl (1963) as to the positions of resonances in collisions between neutral hydrogen atoms and free electrons. The relatively large intensities of the forbidden transitions indicate that the extent of the ion in its excited states may be very large as compared to ordinary atomic dimensions. In the $O^-$ case the relative doublet separation, as extrapolated along the isoelectronic sequence, is used for the identification of the doublet. (auth)

**18359** MORPHOLOGICAL CLASSIFICATION OF E AND SO GALAXIES IN TERMS OF EQUILIBRIUM ISOPLETHS. Edelen, Dominic G. B. (RAND Corp., Santa Monica, Calif.). Astrophys. Space Sci., 3: 56-76(Jan. 1969).

A theory of galactic morphology results from the consideration of isoplethic surfaces in states of geometric equilibrium within the theory of general relativity. In the linearized case, one solves $\nabla^2\psi + p^2\psi = 0$ on the surface of an oblate spheroid with unit semi-major axis and eccentricity $\epsilon$. The surfaces defined by $x^2 + y^2 + z^2/(1-\epsilon^2) = \exp(\psi)$ are then equilibrium isopleths. The resulting morphological system contains two continuous parameters ($\epsilon$ and the norm of $\psi$) and an integer-valued parameter n. The system includes the ellipticals as special cases, and the various available profiles are given for a variety of values of the parameters. The forms are sufficiently varied as to represent NGC 3115, 128, 7332, and IC 3973. These forms cease to be enigmatic for they fit into an orderly sequence progressing out of the ellipticals and have equilibrium interpretations as previously obtained only for the ellipticals. (auth)

**18360** COUNT OF GALAXIES ON PA 83. Veleva, Bojka: Kalinkov, Marin. Izv. Sekts. Astron., Bulg. Akad. Nauk, 2: 151-6(1967).

With the aid of a copy of the Palomar Atlas, the galaxies to about the 19th stellar magnitude were counted. Graphically the points with the same surface density of the galaxies are presented. (Abstr. of Bulg. Sci. Lit.)

**18361** GRAVITATIONAL INSTABILITY OF A ROTATING ANISOTROPIC PLASMA WITH THE INCLUSION OF FINITE LARMOR RADIUS EFFECT. Bhatia, P. K. (Univ. of Jodhpur, India. Univ., Liege). Z. Astrophys., 69: 363-7(1968).

For the longitudinal mode of wave propagation, the gravitational instability of a rotating anisotropic plasma was studied to include the effect of a finite Larmor radius when the unperturbed magnetic field is assumed to be uniform and the axis of rotation is taken along the direction of the magnetic field. The dispersion relation was obtained by using the modified Chew–Goldberger–Low equation. It was found that the instability is still determined by Jeans' criterion. (auth)

**18362** UBV PHOTOMETRY OF STAR CLUSTERS IN THE MAGELLANIC CLOUDS. van den Bergh, Sidney; Hagen, Gretchen L. (Univ. of Toronto, Richmond Hills, Ont.). Astron. J., 73: 569-78(Sept. 1968).

Integrated UBV observations are reporeted for 39 clusters in the Large Magellanic Cloud, 13 clusters in the Small Magellanic Cloud (SMC), and 7 galactic star clusters. Comparison of open clusters in the Galaxy with clusters in the Clouds yields a mean reddening $(E_{B-V}) = 0.20 \pm 0.05$ for young clusters with ages smaller than $3 \times 10^7$ yr. Older clusters with ages between $3 \times 10^7$ and $1 \times 10^9$ yr are found to have a mean reddening $(E_{B-V}) = 0.06 \pm 0.01$. The globular clusters in the Magellanic Clouds do not follow the relation between intrinsic color $(B-V)_0$ and metallicity index Q which had previously been found for galactic globular clusters. This is probably due to systematic differences between the color–magnitude diagrams of Cloud globulars and globular clusters in the Galaxy. Attention is drawn to the existence of very red stars near the tips of the giant branches of many globular clusters in the Magellanic Clouds. Such objects, which may be mild carbon stars, are also observed in the Sculptor system but do not seem to occur in galactic globular clusters. The fact that the W Virginis star in NGC 121 falls on the period–luminosity relation observed in dwarf spheroidal systems emphasizes the similarity between Population II in the Clouds and in some dwarf spheroidal galaxies. In addition to these differences between the old stellar populations in the Galaxy and the Magellanic Clouds, differences also exist between the young stars in these systems. Furthermore, the dust-to-gas ratio in the SMC is found to be at least 10 times smaller than it is near the Sun. It is suggested that the observed differences between the Galaxy and the Magellanic Clouds are due to small differences in helium and (or) heavy element abundance. (BBB)

**18363** A CHARGE BUNCHING APPROACH TO THE GRAVITOHYDRODYNAMIC INSTABILITY. Cuperman, Sami (Tel Aviv Univ., Israel). Astrophys. Space Sci., 3: 229-33(Feb. 1969).

The criterion for the gravitational hydrodynamic instability of an infinite uniform self-gravitating system in uniform translational motion is established by making use of the conservation laws written in the system of coordinates in which the pressure wave produced by an initial density fluctuation is at rest. An analogous method, based on the hydrodynamic formulation of "charge bunching" has been used in the past to establish a criterion for the instabilities of plasma oscillations. (auth)

**18364** STATISTICAL MECHANICS OF A COLLISIONLESS SELF-GRAVITATING SYSTEM. Hohl, Frank; Campbell, Janet W. (Langley Research Center, Hampton, Va.). Astron. J., 73: 611-15(Sept. 1968).

Recently, Lynden-Bell proposed a theory of the mixing phase during which a stellar system approaches a quasi-equilibrium state. Using a new type of statistics related to Fermi–Dirac statistics, he derived a final or quasi-equilibrium distribution. In the present report, computer experiments with a one-dimensional model were performed to determine whether a self-gravitating system will approach the Lynden-Bell distribution. A number of initial distributions with various degrees of departure from a minimum energy or stationary state was investigated. Depending on the initial conditions, it was found that from 80 to 96% of the stars in the system approach the Lynden-Bell distribution. (BBB)

**18365** HIGH CENTRAL DENSITIES IN STELLAR SYSTEMS. Von Hoerner, Sebastian (National Radio Astronomy Observatory, Green Bank, W. Va.). Bull. Astron., 3: 147-61(1968).

The partial differential equation for the development of isolated, spherical, equal-mass star clusters was derived under the assumptions: (a) local virial equilibrium, (b) symmetrical and limited energy exchange, and (c) the escape of stars is negligible. The development of density, radius, and mass of the densest central part was then found. Many tests all gave good agreement with the results of older numerical experiments, in spite of their limited calculation accuracy and small number of stars. Actually, the central development is terminated when either the center runs out of stars or when stellar collisions take over. An original cluster must fulfill two conditions if it shall reach the collisional state within $10^{10}$ yr and before running out of stars. The densest observed centers of elliptical galaxies fulfill the second condition and are very close to the first one, and a few exceptionally dense centers should be expected to be in the state of collisions. It follows that these centers would have about $10^8$ stars with rms velocities of 700 km/sec within a dia of 0.01 parsec, yielding about 20 collisions/yr with collision velocities of almost 2000 km/sec. The assumption that colliding stars become unstable and turn ½% of $mc^2$ into radiation gives a luminosity of $10^{46}$ erg/sec. All of these data seem to fit quasars quite well. The explanation of quasars by stellar collisions in exceptionally dense centers of galaxies appears promising. With one unproven assumption (explosions), and without a single free parameter, a fair fit was obtained for all observed quantities. On the other hand, the details of the production of energy and of its transformation into radiation are not dealt with here and their proper treatment might change the conclusions. Furthermore, the stellar-dynamical development was derived for equal-mass systems, whereas in reality a distribution of masses over a wide range obtains. However, given enough time, the most massive stars (those at the climax of stellar evolution for any given time) will concentrate at the center, and because of the sharp cut-off of the mass spectrum caused by stellar evolution, the assumption of an equal-mass center can be justified on theoretical grounds, as well as from observational data of 2 globular clusters. If all stars in the center are at the climax of their evolution, or close to it, explosive collisions may get much more probable than for unevolved stars. (BBB)

## Cosmology

**18366** (AD-674751) COSMOLOGY WITH INVARIANT COMMUNICATION TIMES. Research Communication No. 64. Edelen, Dominic G. B. (Douglas Aircraft Co., Inc., Huntington Beach, Calif. Advanced Research Lab.). June 1968. 23p. (DAC-5140). CFSTI.

If t represents the usual cosmic-time parameter, with $t_0$ being the present epoch, a "tau-time" is defined by the relation d tau =

R ($t_0$)dt/R (t) where R (t) is the radius of the Universe at time t. Assuming that the results of special relativity hold at each epoch with respect to tau-time, it is shown that any two co-moving bodies that can be connected by light signals have an invariant communication time with respect to tau-time, and the velocity of light is given by C (t) = c/(d tau (t)/dt). Even though this result necessitates certain basic changes, it is shown that the same relations hold among distance, red shift, luminosity, and the Hubble parameter as obtained in classical cosmology, and that observations at the present epoch do not differentiate between tau-time and t-time. Basically, the results show that tau-time is a natural dynamical time for cosmological investigations and its use rearranges the line element in such a way that the time-wise pathology occurs only through a conformal factor. (USGRDR)

**18367** TWO PROBLEMS IN GRAVITATION. I. Rood, Herbert J. (Wesleyan Univ., Middletown, Conn.). Sky Telesc., 37: 152-3(Mar. 1969).

A major discrepancy arises when astronomers try to determine the mass of a cluster of galaxies. The system's mass can be calculated from the motions of the galaxies in it, but when the individual masses of the member galaxies are added, the sum is more than 10 times smaller. There is a certain parallel between this large-scale mass discrepancy and the situation in the solar system when the motions of planets, satellites, and space probes are calculated precisely. These two problems are discussed. (W.D.M.)

**18368** A POSSIBLE COSMOLOGICAL INTERPRETATION OF THE RED SHIFT OF QUASARS. Mattig, W. (Fraunhofer Institut, Freiburg i. B.). Z. Astrophys., 69: 418-28(1968). (In German).

An attempt was made to find a cosmological model describing the observed magnitude–red-shift relation of quasars. If evolutionary effects are neglected, relativistic models with zero cosmological constant ($\Lambda = 0$) do not explain the observations. Therefore, special models with $\Lambda \neq 0$ were investigated with the result that positive curvature and postive cosmological constant can explain the observations satisfactorily, the absolute magnitude of quasars then being nearly the same as that of normal galaxies. The chosen model, however, selected mainly because of simplicity, leads to a too-short time scale ("age of the Universe" $2.7 \times 10^9$ years). (auth)

**18369** CLASSICAL DYNAMICS IN AN EXPANDING UNIVERSE. Kulhanek, J.; Szamosi, G. (Univ. of Windsor, Ont.). Nuovo Cim., 60B: 86-92(Mar. 11, 1969).

The classical dynamics of a test particle in a homogeneous closed Universe is investigated. The canonical method is used to obtain dynamical quantities unambiguously. The picture of the motion is described in the "chronometric" three-space. The Newtonian inertial mass is decreasing with the expanding universe. (auth)

**18370** CHARACTERISTIC COSMOLOGICAL LENGTH. Chernin, A. D. (Ioffe Inst. of Physics and Tech., Moscow). JETP Lett. (USSR) (Engl. Transl.), 8: 391-3(Dec. 5, 1968).

Translated from Zh. Eksp. Teor. Fiz. Pis'ma Redaktsiyu, 8: 633-5(Dec. 5, 1968).

It is concluded that the contemporary value of the radius of curvature a is larger than the characteristic length A (e.g., $a \simeq 10^{29}$ cm at $\rho_m \simeq 2 \times 10^{-31}$ g/cm$^3$). Since a increases with time, there existed in the past an instant $\tau_A$ [$\rho_m(\tau_A)$] ~ $\rho_r(\tau_A) \sim 10^{-22}$ g/cm$^3$, at which the variable length a coincided with the characteristic length A. This instant is unique in a certain sense; if a qualitative change of the large-scale geometric structure of the metagalaxy took place in the past, it possibly occurred precisely in the epoch $\tau \sim \tau_A$. (W.D.M.)

**18371** GRAVITATIONAL INSTABILITY OF SPHEROIDAL EXPANSIONS: A COSMOGONIC FRAGMENTATION MECHANISM. Bird, J. F. (Johns Hopkins Univ., Silver Spring, Md.). Astrophys. Space Sci., 3: 312-29(Feb. 1969).

Expanding flows of self-gravitating gas are common in astronomy and their stability therefore of some concern. Recently, gravitational instability in anisotropic expansions was proposed as an effective mechanism for the fragmentation called for in various cosmogonic hypotheses. (The anisotropy permits strong linear instabilities, while expansion avoids some nonlinear problems.) Here the gravitational stability of spheroidal expansions of rotating gas masses is analyzed in detail. This extends Jeans' static results, and includes the well-known special cases of nonrotating spherical expansion and nonexpanding rotation. Generalized Jeans' criteria for instability are obtained, and in particular, a criterion for the instability to grow exponentially is derived. For an important class of asymptotic flows, the instability strength is explicitly evaluated and it is shown that it is enough to initiate a fragmentation process. From the instability criteria a lower bound to the possible fragment masses is estimated. The Appendix discusses another asymptotic flow, modeling a "high-energy jet" which is highly unstable. (auth)

**18372** NEW HYPOTHESIS CONCERNING THE REDSHIFT. Bellert, Stanislaw (Warsaw Technical Univ.). Astrophys. Space Sci., 3: 268-82(Feb. 1969).

An attempt is presented to explain the red shift in terms of a theory based on two postulates: (1) perfect cosmological principle, and (2) postulate of the uniqueness of electromagnetic wavelength measurements. It is assumed that the space of events is a static space, and the red shift is a consequence of the geometry of that space. In terms of the accepted postulates a theorem has been proved, according to which the luminosity distance D is related to the red shift $\Delta\lambda/\lambda_0$ by $D = cT\,(\Delta\lambda/\lambda_0/1 + \Delta\lambda/\lambda_0)$ where c is the light velocity, and T, the Hubble constant. It is shown that this relation is in agreement with astronomical data concerning the red shift and the distribution of galaxies. The hypothesis does not lead to the necessity of accepting any assumptions concerning the creation of matter at the origin of time or a continuous creation of matter, which have been postulated by certain other theories. (auth)

**18373** MEASUREMENT OF COSMIC MICROWAVE BACKGROUND RADIATION. Penzias, Arno A. (Bell Telephone Labs., Inc., Holmdel, N. J.). IEEE (Inst. Elec. Electron. Eng.) Trans. Microwave Theory Tech., MTT-16: 608-11(Sept. 1968).

Earlier measurements of the effective zenith noise temperature of the 20-ft horn-reflector antenna at the Crawford Hill Lab., Holmdel, N. J., at 4080 Mc yielded a value about 3.5°K higher than expected. This excess temperature is, within the limits of observations, isotropic, unpolarized, and free from seasonal variation. This microwave background radiation is believed to be the remnant of the intense radiation associated with the initial expansion of the Universe, the so-called "big bang." One consequence of the theory is that this radiation is considered to have a black-body spectrum; i.e., the antenna temperature is constant with frequency so long as $hf \leq kT$, where h and k are the Planck and Boltzmann constants and T is the temperature in degrees Kelvin. This relation is valid to $f \simeq 50$ GHz where the effects of atmospheric attenuation become overwhelming. For frequencies less than ~1 GHz, radiation from the Galaxy dominates. Between these two limits measurements have been made in order to obtain the spectrum of the phenomenon. The techniques associated with the measurement of antenna temperature at microwave frequencies are discussed. Some experiments designed to measure cosmic microwave background radiation are described and their results compared. These later results give a very good fit to a 3°K blackbody curve between 1.4 and 35 GHz. (BBB)

### *Planetary Phenomena*

*Refer also to abstract 18311.*

**18374** ION-EXOSPHERE WITH VARIABLE CONDITIONS AT THE BAROPAUSE. Hartle, R. E. (Goddard Space Flight Center, Greenbelt, Md.). Phys. Fluids, 12: 455-62(Feb. 1969).

The model ion-exosphere of Eviatar, Lenchek, and Singer for a nonrotating planet with a static, centered-dipole magnetic field is generalized by permitting the density and temperature to vary over the baropause. In particular, the density and/or temperature are allowed to differ at the conjugate magnetic field points of the baropause. For this case, the ion and electron velocity-distribution functions, satisfying the Vlasov equations in the drift approximation, are constructed. Then, the species densities are determined from the distributions and compared with the corresponding results of Eviatar et al. for the case of uniform density and temperature at the baropause. In addition, the particle current densities, pressures, and temperatures are derived. (auth)

## Atomic and Molecular Physics

*Refer also to abstracts 17448, 17760, 17838, 17848, 18315, 18348, 18351, 18503, 18505, 18532, 18567, 18737, 18758, 18759, 18848, 18873, and 19160.*

**18375** (AD–674295) VARIATIONAL PERTURBATION THEORY CALCULATIONS. Midtdal, John; Aashamar, Kjell; Lyslo, Gudmund (Oslo Univ. (Norway). Inst. for Theoretical Physics). Dec. 5, 1967. 12p. (AFOSR-68-1693). CFSTI.

Numerical calculations for the two-electron systems $1s^2$ 1S, $2p^2$ 3P, 1s2s 1, 3S, and 1s2p 1, 3P have been performed by means of the variational perturbation procedure in order to investigate the domain of convergence of the power series expansions for energy and wave function. A number of figures are presented to

illustrate the various convergence properties. The calculations seem to indicate that a specific atomic system may have discrete states with quadratically integrable wave functions adjacent to the continuum. The introduction of modified definitions of the concept of closed states is proposed. (auth)

**18376** (JAERI-5018, pp 63-4) OPTICAL RADIATION FROM GASES EXCITED BY HIGH-ENERGY ELECTRONS. I. EXCITATION OF NITROGEN AND OXYGEN EFFECT. Nakai, Yohta; Matsuda, Koji; Takagaki, Torao; Kimura, Ki-ichi (Japan Atomic Energy Research Inst., Osaka. Osaka Lab.). (In English and Japanese).

Optical emissions produced in collisions of 1.5-MeV electrons incident on nitrogen molecules were studied in the spectral region from 2500 to 5000 Å. The prominent features of the nitrogen spectrum at a pressure of about 120-mm Hg were the intense $N_2$ second-positive and weak $N_2^+$ first-negative band systems. Evidence was also observed for quenching of the second-positive band system by the addition of oxygen gas. (auth)

**18377** (SC-CR-68-3691) COINCIDENCE STUDY OF $O^+$ ON Kr COLLISIONS. Final Report. Kessel, Quentin C.; Everhart, Edgar (Connecticut Univ., Storrs. Dept. of Physics). Feb. 1, 1966. Contract 74-0522. 20p. Dep. CFSTI.
For Sandia Corp., Albuquerque, N. Mex.

The reaction $O^+ + Kr \rightarrow O^{m+} + Kr^{n+} + (m + n - 1)e$ is studied. The incident oxygen is scattered to angle $\theta$ with charge m+ and the target krypton recoils to angle $\phi$ with charge n+. A coincidence apparatus is used, which enables one to study simultaneously the two particles resulting from the same collision. The two charge states m and n are determined, and the quantity $\bar{Q}_{mn}$, the inelastic energy loss for the (m,n) reaction, is found. Violent large-angle collisions wherein the oxygen is scattered to angles $\theta = 10°$ to 40° are studied. The incident energy ranges from 25 to 230 keV. In the more violent collisions the oxygen is found to be up to 4X ionized and the krypton up to 8X ionized. The ionization probabilities are plotted vs the average inelastic energy loss of the collision. The inelastic energy losses run from 100 to 960 eV. (auth)

**18378** (UCRL-Trans-10322) DEPENDENCE OF SPECIFIC PRESSURE AND ELECTRON IMPACT WIDENING IN THE HIGH PRESSURE MERCURY DISCHARGE UPON STRENGTH OF CURRENT. Rompe, R.; Schulz, P. Translated for Univ. of California, Lawrence Radiation Lab., Livermore, from Z. Phys., 110: 223-32(1938). 21p. Dep. CFSTI.

The dependence of the width of the lines 5770 Å ($2^1P_1 - 3^1D_2$) and 10,140 Å ($2^1P_1 - 2^1S_0$) in the high-pressure mercury discharge upon current strength is measured and traced back to the level broadening. The width of the $3^1D_2$ level varies linearly with current strength. The width of the $2^1P_1$ level is, in contrast, only slightly dependent upon current strength. The measurements confirm the interpretation of the width of the $3^1D_2$ level as being due to electron-impact broadening, and that of the $2^1P_1$ level as due to specific pressure broadening. (auth)

**18379** STARK-MIXING SIGNALS IN THE n = 4 TERM OF SINGLY IONIZED HELIUM. Eck, T. G.; Huff, R. J. (Case Western Reserve Univ., Cleveland). Phys. Rev. Lett., 22: 319-21(Feb. 24, 1969).

Data are presented for signals associated with the crossing of fine-structure levels of a hydrogen-like atom when these levels are excited at a uniform rate and coupled by the application of a static electric field. With modest electric-field strengths, strong crossing signals are seen even when the lowest order of coupling for the two levels involved is third order. (auth)

**18380** A PERTURBATION TREATMENT OF THE HARTREE-FOCK EQUATION FOR $2s^2\ ^1S$ WEAKLY QUANTIZED STATES OF HELIUM-LIKE IONS. Sharma, C. S.; Wilson, R. G. (London Univ.). Acta Phys. Pol., 34: 979-83(Dec. 1968).

The first-order Hartree-Fock (HF) equation for the $2s^2\ ^1S$ states of two-electron atomic systems is solved exactly. The solution is used to evaluate the second-order HF energy exactly and the third-order HF energy with great accuracy. The zero- and first-order terms in the expectation values of $\delta(r)$, $1/r$, $r$ and $r^2$ are calculated for the 2s orbital. The result of this paper for the helium atom is compared with results of other calculations and of experiment. (auth)

**18381** ELECTRON DETACHMENT FROM $H^-$ BY ELECTRON IMPACT. Bely, O. (Observatoire de Nice); Schwartz, S. B. J. Phys., B (London), 2: 159-61(Feb. 1969).

The ionization of $H^-$ by electron impact is computed using several partial wave expansion methods. Results are compared with experiment. (auth) (UK)

**18382** EXCHANGE CROSS SECTIONS FOR THE IONIZATION OF ATOMIC HYDROGEN. Luffman, B. L. (University Coll., London). J. Phys., B (London), 2: 162-6(Feb. 1969).

The theory of electron-impact ionization as developed by Peterkop (1960-63), and by Rudge and Seaton is used to calculate, exchange and nonexchange cross sections for the process $H + e \rightarrow H^+ + e + e$ in the approximation defined by $z' = 0$, $z = 1 + (k/k') - (k/|k-k'|)$ (k and k' are the moments of the outgoing electrons). As these values of z and z' satisfy the condition $z/k + z'/k' = 1/k + 1/k' - (1/|k-k'|)$ the phase factor in the exchange cross section is well defined. (auth) (UK)

**18383** ABSOLUTE CROSS SECTIONS FOR ELECTRON EXCITATION OF THE SECOND POSITIVE BANDS OF NITROGEN. Burns, D. J.; Simpson, F. R.; McConkey, J. W. (Queen's Univ., Belfast). J. Phys., B (London), 2: 52-65(Jan. 1969).

Absolute excitation cross sections for the emission of the second positive bands of nitrogen under electron impact were obtained. Peak-level cross sections for the $v' = 0$, 1, 2 levels of the $c\ ^3\Pi_u$ state were found to be, respectively, $23.5 \times 10^{-18}$, $14.4 \times 10^{-18}$ and $4.9 \times 10^{-18}$ cm². Good agreement is found with the theoretical A coefficients for the relative intensities of the different vibrational bands. The results are compared with those of other workers and various secondary effects observed are discussed. (auth) (UK)

**18384** MOLECULAR HYDROGEN INELASTIC ELECTRON IMPACT CROSS SECTIONS: A SEMICLASSICAL METHOD. Prok, G. M.; Monnin, C. F.; Hettel, H. J. (Lewis Research Center, Cleveland). J. Quant. Spectrosc. Radiative Transfer, 9: 361-9 (Mar. 1969).

Cross sections for ionization and excitation of diatomic molecules by electron impact are calculated using a modification of Gryzinski's semiclassical theory. The theoretical model is described. Specific results are given for molecular hydrogen from the ground state to $E(2s\sigma^1\Sigma_g^+)$, $B(2p\sigma^1\Sigma_u^+)$, $C(2p\pi^1\Pi_u)$, and $D(3p\pi^1\Pi_u)$ states and for ionization. Calculations were carried out to 360 eV. In addition, some results for the nitrogen molecule are presented. The excitation calculations are compared to Born and Born-Ochkur approximations. This comparison shows that the molecular model presented gives acceptable estimates of cross sections for excitation of ground-state molecular hydrogen. The ionization results for both molecular hydrogen and molecular nitrogen are in good agreement with experimentally obtained cross sections. It was found that better results were obtained for both excitation and ionization by using the average orbital electron energy for the average kinetic energy of the bound electron instead of the ionization potential. (auth) (UK)

**18385** EXCITATION RESONANCES FOR THE PRODUCTION OF METASTABLE ATOMS IN LOW-ENERGY ARGON ION-ATOM COLLISIONS. Haugsjaa, Paul O. (Univ. of Denver); Amme, Robert C.; Utterback, Nyle G. Phys. Rev. Lett., 22: 322-4 (Feb. 24, 1969).

Metastable argon atoms are found to be forward scattered along with ground-state atoms after $Ar^+ + Ar$ charge-transfer collisions. By use of a detection technique involving Penning ionization of acetylene, it was found that the cross section for metastable excitation has a magnitude of the order of $10^{-3}$ Å² and exhibits two distinct low-energy resonances as a function of incident $Ar^+$ energy. (auth)

**18386** BACKSCATTERING PROCESS OF MONOCHROMATIC ELECTRONS. Verdier, Pierre; Arnal, Floreal (CNRS, Toulouse). Compt. Rend., Ser. A, B, 267: 1443-6(Dec. 23, 1968). (In French).

The coefficient of backscattering was measured for samples bombarded by a monochromatic electron beam (energies between 50 and 1200 keV). The experiments, which were carried out on 26 elements, show how this coefficient varies as a function of the energy of the incident electrons and the density and nature of the target. (tr-auth)

**18387** ORIGIN OF SECONDARY ELECTRONS EJECTED FROM GAS-COVERED SURFACES BY FAST NEUTRAL BEAMS. Amme, Robert C. (Univ. of Denver). J. Chem. Phys., 50: 1891-83(Feb. 15, 1969).

Features of experimental data on ejection of secondary electrons from gas-covered surfaces by fast neutral beams are summarized. Secondary electron emission for neutral species colliding at normal incidence with a gas-covered metal target is plotted as a function of excess cms energy. The principal adsorbed species is assumed to be water, and curves are shown for He, $O_2$, Ar, and $N_2$-CO. The curves are closely parallel and all within a factor of roughly 2 to 3 at any energy in the eV range. The number of electrons ejected at a given energy increases with the mass of the incoming particle. (A.G.W.)

**18388** THEORETICAL CALCULATIONS OF THE d-, f-, AND g-ELECTRON TRANSITION SERIES. Griffin, Donald C. (Purdue Univ., Lafayette, Ind.); Andrew, Kenneth L.; Cowan, Robert D. Phys. Rev., 177: 62-71(Jan. 5, 1969).

Self-consistent-field calculations of the effective quantum numbers for nd, nf, and ng electrons for a large number of atomic configurations from Z = 2 to 126 have been made using a Hartree plus statistical-exchange method with first-order correlation and relativistic energy corrections. The computed binding energies agree with experimental values where known (67 configurations), with an average deviation of 1.5%. The sudden decreases with increasing Z in the effective quantum numbers of the d and f electrons, which precede the onset of the known transition series, are accurately predicted. An interpretation of these changes in effective quantum number is given in terms of the effective potential. The probable existence of a 7d, 6f, or 5g transition series beginning at about Z = 122 is examined. The computed abrupt decrease in effective quantum number of the 7d and 6f electrons at Z = 120, and of the 5g electron at Z = 121, indicates the possible participation of all of these electrons in the ground configuration of such elements. Relativistic corrections strongly affect the calculated relative energies of different possible ground configurations of the elements Z = 121 to 126. (auth)

**18389** SUMMARY OF EXCHANGE PERTURBATION CALCULATIONS FOR $H_2$ AT LARGE SEPARATIONS. Hirschfelder, Joseph O.; Certain, Phillip R. (Univ. of Wisconsin, Madison. Univ. of Florida, Gainesville). Int. J. Quant. Chem., Symp. No. 2, 125-35(1968).

From Symposium on Atomic, Molecular, and Solid-State Theory and Quantum Biology, Sanibel Island, Florida. See CONF-680116.

This paper is a summary and appraisal of the recent work of the authors together with Kolos and Wolniewicz which applied four types of perturbation procedures to the calculation of the energy of the ground state and first excited state of the hydrogen molecule at large separations. All of the perturbation techniques gave good values for the exchange energy but less accurate values for the Coulombic energy. The reasons why the second-order Eisenschitz–London energy approaches one-half of the correct limit at large separations are discussed. There seems to be no uniqueness to the orders in an exchange perturbation problem. (auth)

**18390** POLARIZATION OF BALMER-ALPHA RADIATION FROM p + He CHARGE-TRANSFER COLLISIONS. Belanger, Michael G.; Soltysik, Edward A. (Univ. of Massachusetts, Amherst). J. Chem. Phys., 50: 1900-1(Feb. 15, 1969).

The polarization and the total relative intensity of the Balmer-$\alpha$ radiation produced in charge-exchange collisions of protons on helium are shown for the proton-energy range from 3 to 26 keV. The Balmer-$\alpha$ radiation results from the following transitions: 3S → 2P, 3P → 2S, and 3D → 2P. The expression for the intensity of the Balmer-$\alpha$ light emitted from a point source z cm from the aperture was integrated over the lens width with the appropriate values for the radiative transition probabilities inserted. From this it was concluded that, in this energy range, less than 8% of the total observed light arises from the 3S state and that the dominant contribution arises from the 3D state. (A.G.W.)

**18391** RADIATIVE CAPTURE OF ELECTRONS BY CHLORINE, BROMINE, AND IODINE ATOMS. Rothe, Dietmar E. (Cornell Aeronautical Lab., Inc., Buffalo). Phys. Rev., 177: 93-9(Jan. 5, 1969).

Absolute intensities were measured in the continuous emission spectrum resulting from electron attachment to the halogen atoms in a shock-heated plasma seeded with sodium halides. The intensity measurements were used to determine new photodetachment cross sections for the negative chlorine, bromine, and iodine ions in the wavelength region between 3000 and 4000 Å. These cross sections are presented here and, where possible, are compared with theoretical and experimental values obtained by other methods. For the case in which the halogen atom is left in the ground state ($^2P_{\frac{3}{2}}$), the present experiments give photodetachment cross sections of $1.2 \times 10^{-17}$ cm$^2$ for $Cl^-$, $2.0 \times 10^{-17}$ cm$^2$ for $Br^-$, and $2.2 \times 10^{-17}$ cm$^2$ for $I^-$ near the detachment thresholds. (auth)

**18392** DIRECT DETERMINATION OF PURE-STATE DENSITY MATRICES. III. PURELY THEORETICAL DENSITIES VIA AN ELECTROSTATIC-VIRIAL THEOREM. Clinton, William L.; Henderson, George A.; Prestia, John V. (Georgetown Univ., Washington, D. C.). Phys. Rev., 177: 13-18(Jan. 5, 1969).

A combined electrostatic–virial theorem is introduced and used to derive a differential equation for the scale factor $\zeta$ in a diatomic molecule. This equation can either be used to compute $d\zeta/dR$ or it can be integrated to yield

$$\zeta(\bar{R}) = \left(\frac{T(\bar{R}_0)}{T(\bar{R})}\right)^{\frac{1}{2}} \left(\zeta(\bar{R}_0) - \frac{1}{2T(\bar{R}_0)} \int_{\bar{R}_0}^{\bar{R}} \frac{2F(R) - RdF(R)/dR}{T(R)^{\frac{1}{2}}}\, dR\right),$$

where R is the internuclear distance, $\bar{R} \equiv \zeta R$, $F = \langle -\partial V_1/\partial R \rangle$, with $V_1$ the one-electron potential, $T \equiv \langle \Sigma_i - \frac{1}{2}\nabla_i^2 \rangle$, and $\bar{R}_0$ is an integration limit. It is shown that if $\zeta(\bar{R}_0)$ is a variational scale factor, then $\zeta(\bar{R})$ is also a variational scale factor provided the electron density $\rho_1$ involves no other unoptimized variational parameters. Unlike the conventional variational expression for $\zeta$, which contains two-electron integrals, the above formula involves only the one-electron force and kinetic-energy integrals. Using this $\zeta$, electron densities and energies are calculated for $H_2^+$, $H_2$, $He_2$, and $Li_2$ and compared with experimental and variationally calculated values. Qualitative agreement is obtained in general, and, in particular, the theoretical energy curve for $He_2$ is in very good agreement with the best variational results for 1.5 a.u. < R < ∞. It is also shown that the electrostatic–virial theorem can be used as a condition in continuing density-matrix calculations from R to R + ΔR. (auth)

**18393** DIRECT DETERMINATION OF PURE-STATE DENSITY MATRICES. IV. INVESTIGATION OF ANOTHER CONSTRAINT AND ANOTHER APPLICATION OF THE P EQUATIONS. Clinton, William L.; Lamers, Guillermo B. (Georgetown Univ., Washington, D. C.). Phys. Rev., 177: 19-27(Jan. 5, 1969).

An additional theorem of the Hellman–Feynman variety is used in conjunction with the equations derived in paper II for the first-order density matrix. This particular theorem due to Parr relates the energy difference $E(\lambda') - E(\lambda)$ to a "parameter-transition density" $\rho(\lambda', \lambda)$. It is shown that $E(\lambda') - E(\lambda)$ can be used as a constraint on either $\rho(\lambda')$ or $\rho(\lambda)$. An additional application of the P equations as a density-fitting technique is investigated. That is, given a set of expectation values in some basis $\Psi$, one can use the P equations to generate the density matrix that corresponds to these expectation values in some other basis $\chi$. Several helium-atom Hartree–Fock densities are fitted to smaller bases with various sets of operators. Density graphs are given for comparison. (auth)

**18394** DIRECT DETERMINATION OF PURE-STATE DENSITY MATRICES. V. CONSTRAINED EIGENVALUE PROBLEMS. Clinton, William L.; Galli, Anthony J.; Henderson, George A.; Lamers, Guillermo B.; Massa, Louis J.; Zarur, John (Georgetown Univ., Washington, D. C.). Phys. Rev., 177: 27-33(Jan. 5, 1969).

A density-matrix approach to constrained eigenvalue problems is presented. It is shown that all of the linearly independent eigenvectors of an Hermitian matrix can be generated with the idempotency equations (P equations) developed in previous papers of this series. In particular, the method is applied to variational calculations in $H_2^+$ and He. Since the local-energy method assumes eigenvalue form, it also can be formulated in terms of the P equations. Various local energies for $H_2^+$ and He are calculated. Direct methods of incorporating local energies as constraints are suggested. An orthogonal operator formalism for the P equations is given. Such operators $O_k, O_l$ have the property that $\mathrm{Tr}O_kO_l = 0$ for $k \neq l$. The iterative P equations, then, assume the simple form $P_{n+1} = \mathscr{P}_n + \Sigma_k[(O_k - \mathrm{Tr}\mathscr{P}O_k)/\mathrm{Tr}O_k^2]O_k$, where $\mathscr{P} \equiv 3P^2 - 2P^3$ and the constraints, $\mathrm{Tr}PO_k = O_k$, are now identically satisfied. (auth)

**18395** DIRECT DETERMINATION OF PURE-STATE DENSITY MATRICES. I. SOME SIMPLE INTRODUCTORY CALCULATIONS. Clinton, William L.; Nakhleh, Jamil; Wunderlich, Francis (Georgetown Univ., Washington, D. C.). Phys. Rev., 177: 1-6(Jan. 5, 1969).

A method is developed for the semiempirical determination of an electron density in small diatomic molecules. The method involves primarily the electrostatic and virial theorems and empirical potential curve data. The density has been determined, using Slater-type basis functions, for the molecules $H_2^+$, $H_2$, $He_2$, $Li_2$, and $N_2$. Expectation values are calculated and compared to exact or Hartree–Fock values. A theoretical discussion of the semiempirical densities via a natural-orbital analysis is given. These analyses show that (a) the electrostatic and virial theorems are effective when used to determine unknown parameters in a first-order density but that (b) some additional means must be provided to ensure N representability. (auth)

**18396** SPECIFIC ENERGY LOSS OF HEAVY IONS IN Al, Ag, AND Au. Albrecht, H.; Muenzel, H. (Kernforschungszentrum, Karlsruhe, Ger.). Z. Phys., 220: 381-93(1969). (In German).

Using a $^{252}Cf$ fission source and two semiconductor detectors at 180°, the specific energy loss of heavy ions in Al, Ag, and Au foils was measured. The agreement with the results of Moak and Brown, and of Kahn and Forgue is better than 15%. The energy loss predicted by Lindhard is 10 to 25% lower than the measured values. A better agreement, especially for absorbers with low atomic num-

ber Z, is achieved by a semiempirical formula proposed by Münzel. (auth)

**18397** CHARGE EXCHANGE OF PROTONS ON ALKALI-ELEMENT ATOMS. Vinogradov, A. V.; Presnyakov, L. P.; Shevel'ko, V. P. (Lebedev Inst. of Physics, Moscow). JETP Lett. (USSR) (Engl. Transl.), 8: 275-8(Nov. 5, 1968).

Translated from Zh. Eksp. Teor. Fiz., Pis'ma Redaktsiyu, 8: 449-52(Nov. 5, 1968).

A numerical calculation was made of the effective cross section for proton–atom charge exchange with production of a hydrogen atom in the Brinkman–Kramers approximation. The calculation was performed with an M-20 electronic computer using a universal program that made it possible to calculate the charge-exchange cross sections of protons with arbitrary atoms, with allowance for the contributions of all the electron shells of the target atom. Results of the calculations are compared with the experimental data for cesium, potassium, and rubidium. (M.H.R.)

**18398** THERMAL ION–MOLECULE REACTION RATE CONSTANTS AT PRESSURES UP TO 10 TORR WITH A PULSED MASS SPECTROMETER. REACTIONS IN METHANE, KRYPTON, AND OXYGEN. Durden, D. A.; Kebarle, P.; Good, A. (Univ. of Alberta, Edmonton). J. Chem. Phys., 50: 805-13(Jan. 15, 1969).

A mass spectrometer for high-pressure ion–molecule reaction studies was constructed using a pulsed 4-keV electron beam and pulsed "gate-open" mass-spectrometer detection. The ions drift out of the field-free ion source by diffusion and mass flow. Pressures up to 10 torr can be used and the ion-reaction times can be as long as several hundred microseconds. The system is specially suited for study of reactions with very small rate constants, long sequences, and reactions dependent on third-body deactivation. Also when reverse reactions are operative the establishment of the equilibrium can be directly followed. The thermal rate constants for the reactions of $Kr^+$ with $CH_4$, and $CH_3^+$ and $CH_2^+$ with $CH_4$, were measured. The reaction of $O_4^+$ with $O_2$ to form $O_6^+$ is found to be third order, proceeding with a rate constant $k = 2.8 \times 10^{-30}$ $cm^6$ $molecules^{-2} \cdot sec^{-1}$ at 298°K. The activation energy for the reaction is negative and equal to 1 to 2 kcal/mole. The equilibrium constants for the reaction $O_4^+ + 2O_2 \rightleftharpoons O_6^+ + O_2$ were determined over the temperature range 295° to 350°K. A Vant Hoff plot of the equilibrium constant gives $D(O_6^+ - O_2) \simeq 10$ kcal/mole. The equilibrium constants and bond-dissociation energy are in very good agreement with earlier results by Yang and Conway. Interesting comparisons with the $N_4^+$ formation in nitrogen can be made. (auth)

**18399** NONRESONANT COHERENT SCATTERING OF GAMMA RAYS. Ghose, A. M. (Bose Inst., Calcutta). Proc. Nucl. Phys. Solid State Phys. Symp., 1968, Madras, 85-96(1968).

From Nuclear Physics and Solid State Physics Symposium, Madras, India. See CONF-680212.

Coherent scattering of gamma rays occurs mainly through the nonresonant processes of Rayleigh scattering, nuclear Thomson scattering, and Delbruck scattering. The elastic scattering of gamma rays of not too high energies is dominated by Rayleigh scattering or the cooperative scattering of photons by the bound electrons of an atom. Nuclear Thomson scattering may be described classically as a process in which the nucleus as a whole is set into vibration by the incident radiation followed eventually by the dissipation of energy in the form of radiation of the same frequency as the incident photon. The intensity of the nuclear Thomson process can be easily calculated by extending Thomson's classical equation for the electron to the nuclear case. Unless $q = (2h\gamma/c) \sin \theta/2$, the momentum transferred by the photon during the elastic encounters is very high or the atomic number of the scatterer is too low, nuclear Thomson scattering forms a negligible part of the total coherent scattering intensity. Delbruck scattering is an interesting second-order effect predicted by quantum electrodynamics, which corresponds to the virtual production of electron–positron pairs and their subsequent annihilation. Attention is confined here to q less than 2.5 mc (m = electronic mass) and $h\nu$ less than 1.5 MeV; hence the nonresonant coherent scattering is considered almost entirely in terms of the Rayleigh process alone. (TSS)(auth)

**18400** DIRECT DETERMINATION OF PURE-STATE DENSITY MATRICES. II. CONSTRUCTION OF CONSTRAINED IDEMPOTENT ONE-BODY DENSITIES. Clinton, William L.; Galli, Anthony J.; Massa, Louis J. (Georgetown Univ., Washington, D. C.). Phys. Rev., 177: 7-13(Feb. 5, 1969).

A formalism is developed for the determination of a constrained idempotent one-body density matrix $\underline{P}$. The method ensures pure-state representability in the Hartree–Fock sense. This is accomplished by minimizing the quantity $Tr(\underline{P}^2 - \underline{P})^2$ subject to either empirical or theoretical constraints. The method leads to an iterative matrix equation of the form $\underline{P}_{n+1} = 3\underline{P}_n^2 - 2\underline{P}_n^3 + \sum \lambda_k^{(n)} \underline{Q}_k$, where $-\lambda_k$ is the kth Lagrangian multiplier pertaining to the constraint $Tr\underline{P}\underline{Q}_k = O_k$, and $O_k$ is the expectation value of the observable $\underline{Q}_k$. Applications to several diatomic molecules are reported using the electrostatic and virial theorems as empirical constraints. Several calculations are carried out in order to corroborate the following result: If the above iterative equations are constrained with a sufficient number of bona fide Hartree–Fock conditions, the solution is the Hartree–Fock $\underline{P}$ matrix. (auth)

**18401** AUTOIONIZATION: ASTROPHYSICAL, THEORETICAL, AND LABORATORY EXPERIMENTAL ASPECTS. Symposium on Atomic Interactions and Space Physics held August 10–11, 1965, at Greenbelt, Md. Temkin, Aaron (ed.). Baltimore, Mono Book Corp., 1966. 164p. $5.00. (CONF-650852).

Separate abstracts were prepared for seven of the eight papers included. No abstract was prepared for a paper on autoionization effects in ultraviolet absorption spectra of hot gases. (A.G.W.)

*For abstracts of individual papers see: 18402–18408.*

**18402** ASTROPHYSICAL IMPLICATIONS OF AUTOIONIZATION. Goldberg, Leo (Harvard Coll. Observatory, Cambridge, Mass.). pp 1-23 of Autoionization: Astrophysical, Theoretical, and Laboratory Experimental Aspects. Temkin, Aaron (ed.). Baltimore, Mono Book Corp., 1966.

From Symposium on Atomic Interactions and Space Physics, Greenbelt, Md. See CONF-650852.

Ways in which autoionization plays a role in formation of astrophysical spectra are reviewed. Autoionization as a source of Fraunhofer lines is considered, and problems in observation of autoionizing lines in astrophysical spectra are pointed out. The importance of autoionizing levels in the process of dielectronic recombination and in increasing the rates of collisional ionization and photoionization are discussed. It is suggested that autoionizing effects may help to explain element abundance discrepancies encountered in astrophysics. (A.G.W.)

**18403** DIELECTRONIC RECOMBINATION. Burgess, Alan (University Coll., London). pp 25-31 of Autoionization: Astrophysical, Theoretical, and Laboratory Experimental Aspects. Temkin, Aaron (ed.). Baltimore, Mono Book Corp., 1966.

From Symposium on Atomic Interactions and Space Physics, Greenbelt, Md. See CONF-650852.

Calculation of the rates for dielectronic recombination processes in astrophysical situations from excitation-cross-section data is described. Inclusion of these rates largely removes the discrepancy between coronal temperatures deduced from ionization balance calculations and those from observed Doppler line broadening. (A.G.W.)

**18404** RESONANCES IN CROSS SECTIONS: THEIR NATURE AND ORIGIN. Gerjuoy, E. (Univ. of Pittsburgh). pp 33-53 of Autoionization: Astrophysical, Theoretical, and Laboratory Experimental Aspects. Temkin, Aaron (ed.). Baltimore, Mono Book Corp., 1966.

From Symposium on Atomic Interactions and Space Physics, Greenbelt, Md. See CONF-650852.

Features of resonant scattering in electron-collision and related processes are reviewed qualitatively. Methods of distinguishing resonant from nonresonant effects are discussed and some examples are shown. Phase shifts in scattering are compared to resonant behavior of the classical stretched string. It is suggested that the existence of long-lived quasi-stable autoionizing states implies the existence of resonant structure in quantum mechanical cross sections; conversely, the observation of resonant structure in electron scattering cross sections implies the existence of long-lived states whose decay mechanism often, but not necessarily, will be autoionization. Procedures for accurate prediction of these resonances are considered briefly. (A.G.W.)

**18405** ART AND SCIENCE OF CALCULATING AUTOIONIZATION. Temkin, A. (Goddard Space Flight Center, Greenbelt, Md.). pp 55-76 of Autoionization: Astrophysical, Theoretical, and Laboratory Experimental Aspects. Temkin, Aaron (ed.). Baltimore, Mono Book Corp., 1966.

From Symposium on Atomic Interactions and Space Physics, Greenbelt, Md. See CONF-650852.

Recent developments in methods of calculating autoionization are reviewed. The twin aspects of autoionization as a bound state and scattering phenomenon are pointed out. The nonadiabatic theory as applied to treatment of autoionization as a scattering problem is described briefly. Two methods for description and calculation of autoionization states as quasi-bound states are discussed. (A.G.W.)

**18406** CLOSE-COUPLING CALCULATIONS AND RESULTS. Burke, P. G. (Atomic Energy Research Establishment, Harwell, Eng.). pp 77-97 of Autoionization: Astrophysical, Theoretical, and Laboratory Experimental Aspects. Temkin, Aaron (ed.). Baltimore, Mono Book Corp., 1966.

From Symposium on Atomic Interactions and Space Physics, Greenbelt, Md. See CONF-650852.

The close-coupling method of treating scattering problems, in which autoionizing states are taken into consideration, is described. The method is based on the eigenstate expansion of the total wave function. Results obtained for electron scattering by singly ionized He are included. It is concluded that the close-coupling expansion provides a very convenient method of determining the resonant structure of the amplitude for systems in which only a few channels are important. (A.G.W.)

**18407** M-MATRIX EXTRAPOLATION METHODS. Smith, Kenneth (London Univ.). pp 99-109 of Autoionization: Astrophysical, Theoretical, and Laboratory Experimental Aspects. Temkin, Aaron (ed.). Baltimore, Mono Book Corp., 1966.

From Symposium on Atomic Interactions and Space Physics, Greenbelt, Md. See CONF-650852.

The development of the M-matrix formalism for scattering problems, by which autoionizing levels can be predicted, is reviewed. Application of the formalism to scattering of electrons by hydrogen atoms by a group at the Latvian Academy of Sciences at Riga is described. These results suggest that the long-range tails of atomic potentials may be sufficiently attractive to generate an infinite number of resonances. (A.G.W.)

**18408** AUTOIONIZATION SPECTRA OF THE NOBLE GASES. Madden, R. P.; Codling, K. (National Bureau of Standards, Washington, D. C.). pp 129-51 of Autoionization: Astrophysical, Theoretical, and Laboratory Experimental Aspects. Temkin, Aaron (ed.). Baltimore, Mono Book Corp., 1966.

From Symposium on Atomic Interactions and Space Physics, Greenbelt, Md. See CONF-650852.

Experiments on the absorption spectra for noble gases in the energy range 20 to 180 eV, in which the National Bureau of Standards 180-MeV electron synchrotron was used as a light source, are reviewed. The positively identified resonances observed are discussed in two classes: those due to one-electron excitation processes and those due to excitation of two electrons simultaneously. These results indicate that autoionizing states are extremely numerous. (A.G.W.)

**18409** PROPERTIES AND METHODS OF INTERPRETATION OF RARE-EARTH SPECTRA. Goldschmidt, Z. B. (Hebrew Univ., Jerusalem). pp 411-57 of Spectroscopic and Group Theoretical Methods in Physics. Block, F. (ed.). New York, John Wiley and Sons, Inc., 1968.

The extreme complexity of rare-earth spectra is attributable to two factors, for which considerable discussion is given, namely: (1) competition between configurations, and (2) competition between interactions. In interpreting the rare-earth spectra, two main problems were considered; (1) evaluation of the strengths of various interactions within the configurations, and (2) evaluation of the various configuration interactions and the repulsions they induce on the energy levels. Complete understanding of many third, second, and first rare-earth spectra resulted, for which tabular data are given. Very good agreement between theory and experiment was achieved. 55 references. (L.M.T.)

**18410** THE USE OF EFFECTIVE INTERACTIONS IN THEORETICAL CALCULATIONS OF TRANSITION ELEMENTS SPECTRA. Shadmi, Y. (Hebrew Univ., Jerusalem). pp 387-401 of Spectroscopic and Group Theoretical Methods in Physics. Block, F. (ed.). New York, John Wiley and Sons, Inc., 1968.

The author's use of effective interactions in order to improve the fit between theory and experiment in atomic spectroscopy is summarized. Specific tabular data are given on the Fe II and Fe III groups, listing the effective-interaction parameters and mean errors for various calculations for each group for various configurations. The Slater approximation was used, and it is pointed out that the changes in the values assumed by any of the Slater parameters never exceeded 10% of their values, and in most cases, the change was even much smaller. It is concluded that effective interactions can be used as a tool for summing up the infinite series of the second-order perturbation theory. For a given Hamiltonian, this tool has two weaknesses: (1) it ignores higher-order perturbation terms; and (2) it assumes a constant difference between the levels of the perturbing configuration and the levels of the perturbed one, which is a good assumption only if the perturbing configuration lies sufficiently far away. It is also concluded that, for the transition elements, the possibility of pushing on with the use of effective interactions is exhausted, until other ways of improving the approximations are used. It is possible a more accurate Hamiltonian may be necessary. (TSS)

**18411** THE ATOMIC PHOTOEFFECT FOR PHOTON ENERGIES 1 TO 2000 keV. Rakavy, G.; Ron, A. (Hebrew Univ., Jerusalem). pp 175-202 of Spectroscopic and Group Theoretical Methods in Physics. Block, F. (ed.). New York, John Wiley and Sons, Inc., 1968.

Comparatively accurate calculations of photoelectric cross sections for many atoms and energies are reported. Contributions of high atomic shells were evaluated and investigated rather carefully. The calculations were performed with various atomic potentials, so as to obtain some estimate for errors in the photoelectric cross sections resulting from uncertainties in the effective atomic fields. The potentials used are taken to be almost as accurate as Hartree–Fock potentials and thought to yield results accurate within a few per cent. Derivation of the general expressions for the cross sections are included, as well as the numerical procedures employed in evaluating these expressions and checks on the accuracy of the calculations. (auth) (TSS)

**18412** OPTICAL DOUBLE RESONANCE STUDIES OF EXCITED STATES OF Tm I WITH MICROSECOND LIFETIMES. Budick, B.; Simievic, A. (Hebrew Univ., Jerusalem). pp 161-5 of Spectroscopic and Group Theoretical Methods in Physics. Block, F. (ed.). New York, John Wiley and Sons, Inc., 1968.

Levels at 17,343, 17,614, and 19,754 $cm^{-1}$ were studied, as well as other levels belonging primarily to the $(4f)^{12}\ 5d(6s)^2$ configuration. Precise measurements were made on the hyperfine structure and Landé g factors of the first two states. Results verify a suggestion by Racah of a coupling scheme for thulium, leading to very long-lived excited states that permit high-precision determination of hfs constants and g values. (L.M.T.)

**18413** SECONDARY ELECTRON EMISSION PRODUCED BY RELATIVISTIC PRIMARY ELECTRONS IN HIGH ELECTRIC FIELDS. Bartashyus, I.; Pranyavichyus, L. (Kaunas Polytechnic Inst., USSR). Liet. Fiz. Rinkinys, Liet. TSR Mokslu Akad., Liet. TSR Aukst. Mokyklos, 8: No. 1–2, 293-9(1968). (In Russian).

Secondary electron emission from thick Al targets bombarded by primary electrons having energies over the range 6 to 20 MeV was investigated. The angle of incidence of primary electron was changed over the range 0 to 70. These experiments show that the secondary-electron yield is proportional to the energy dissipated by electrons near the surface of a solid in the region where escaping secondary electrons are produced. An investigation of secondary-electron emission in high electric fields showed that the yield of secondary electrons is independent of the strength of the electric field. (auth)

**18414** HYDROGEN WAVE FUNCTIONS DESCRIBING LEVELS WITH WIDTH. Yanavichus, A.; Shugurov, V. (Vilnyus State Univ., USSR. Siauliai State Pedagogical Inst., USSR). Liet. Fiz. Rinkinys, Liet. TSR Mokslu Akad., Liet. TSR Aukst. Mokyklos, 8: No. 1–2, 47-51(1968). (In Russian).

The hydrogen problem has been solved when energy is complex. From vanishing of the wave function at large distance the mutual dependence between the imaginary parts of energy and momentum is established. (auth)

**18415** INELASTIC SCATTERING OF FAST ELECTRONS FROM BENZENE. Lyash, A. V.; Poshyunaite, N. P.; Bolotin, A. B. (Vilnyus State Univ., USSR). Liet. Fiz. Rinkinys, Liet. TSR Mokslu Akad., Liet. TSR Aukst. Mokyklos, 8: No. 1–2, 119-27(1968). (In Russian).

The Born approximation has been used to obtain an expression for the total cross section for excitation of the two lower molecular electronic states by inelastic electron scattering. Effective cross sections averaged over all directions of an incident electron are calculated for the excitations to the lower excited levels of $\pi$ electrons in benzene by means of the Born approximation with the help of the MO LCAO approximation. Results of calculation show that the $\pi$ electrons in benzene are easily excited to the lowest excited levels by electrons. (auth)

**18416** EXACT EXPRESSION FOR THE AMPLITUDE OF PHOTON SCATTERING ON HYDROGEN ATOMS AND THE LAMB SHIFT IN THE NONRELATIVISTIC APPROXIMATION. Gránovskii, Ya. I. (Inst. of Nuclear Physics, Alma-Ata, USSR). Zh. Eksp. Teor. Fiz., 56: 605-13(Feb. 1969). (In Russian).

Closed formulas are derived for the photon–hydrogen-atom scattering amplitude (elastic and combinational). The formulas are exact in the sense of taking into account the external field. The Lamb shift of the levels of hydrogen-like atoms are calculated in the nonrelativistic approximation with aid of the formulas. (auth)

**18417** CALCULATION OF THE ATOMS WITH EQUIVALENT ELECTRONS. Kantseryavichyus, A. (Inst. of Physics and Mathematics, Vilnyus, USSR). Liet. Fiz. Rinkinys, Liet. TSR Mokslu Akad., Liet. TSR Aukst. Mokyklos, 8: No. 1-2, 27-38(1968). (In Russian).

Atomic orbitals expressed as sums of spherical harmonics are used to construct the wave function of the equivalent electron shell. Methods of expression and improvement of the radial part of the wave functions are considered. Energy matrix elements are given in the case when part of the equivalent electrons have various radial functions and when nonorthogonal orbitals are used. Numerical calculations are carried out to improve the energies for ground-state C and $N^+$. (auth)

**18418** MUONIUM AND MUONIUM CHEMICAL COMPOUNDS. Szpilecki, Jozef (Polytechnic Inst., Warsaw). Postepy Fiz., 82: 689-99(1968). (In Polish).

To solve the problem of $\mu^+$-meson depolarization in interaction with materials, the concept of the muonium hydrogen-like atom ($\mu^+e^-$) and its possible chemical reactions and compounds with the acceptor are discussed. (auth)

**18419** ENERGY AND ENERGY-ANGULAR DISTRIBUTION OF EXCITED BAND ELECTRONS DURING FAST PRIMARY ELECTRON IMPACT ON SODIUM. Arendt, P. (Physikalisch-Technische Institut, Berlin). Phys. Status Solidi, 31: 713-22 (Feb. 1, 1969). (In German).

For sodium, a calculation is made of the excitation function from core bands obtained from collision with fast primary electrons. It is found that the excitation from the core bands is considerably less anisotropic than the excitation from the conduction band. Using the calculated distribution, the secondary yield calculated on the basis of a transport theory agrees with the experimental yield within the range of accuracy to be expected. (auth)

**18420** MEASUREMENT OF THE $2^2S_{\frac{1}{2}} - 2^2P_{\frac{1}{2}}$ INTERVAL IN ATOMIC HYDROGEN. Kaufman, S. L.; Lamb, W. E. Jr.; Lea, K. R.; Leventhal, M. (Yale Univ., New Haven). Phys. Rev. Lett., 22: 507-9(Mar. 17, 1969).

The $2^2S_{\frac{1}{2}} - 2^2P_{\frac{1}{2}}$ interval has been determined to be 9911.38(3) MHz in atomic hydrogen, by using the rf electric dipole transitions $\alpha a$ and $\alpha b$. When this result is combined with the current experimental values of the $2^2S_{\frac{1}{2}} - 2^2P_{\frac{1}{2}}$ interval, a value $\Delta E_H$ = 10 969.20(6) MHz is obtained. The corresponding value for $\alpha^{-1}$ is 137.0350(4). (auth)

**18421** DYNAMICAL SYMMETRY OF DISCRETE SPECTRUM OF RELATIVISTIC HYDROGEN ATOM. Malkin, I. A.; Man'ko, V. I. (Moscow Physical-Technical Inst.). Yadern. Fiz., 9: 184-9(Jan. 1969). (In Russian).

It is shown that states of the discrete spectrum of the relativistic hydrogen atom and of the Biedenharn symmetric model may be treated by a single infinite-dimensional representation of the O(4,2) ⊗ SU(2) group. A possible classification of states of the discrete spectrum is presented by means of degenerate irreducible representations of the O(4,2) group which are convenient for hadron physics. Dynamical symmetry of the Pauli electron in the Coulomb field is discussed. (auth)

**18422** MUON DEPOLARIZATION AT THE μ-MESOATOM PRODUCTION ON NUCLEI WITH NON-ZERO SPIN. Bukhvostov, A. P. (Tomsk State Univ.). Yadern Fiz., 9: 107-13(Jan. 1969). (In Russian).

Muon residual polarization at cascade transitions in mesoatoms for the nuclear spin from 0 to $11/2$ is calculated for specific values of initial orbital momentum. Hyperfine splitting of excited levels is assumed to be large as compared to their width. When calculating the polarization the possibility of the Auger transitions between sublevels in the hyperfine structure of the mesoatom K shell is considered. (auth)

**18423** PHASE-SPACE METHOD FOR THE CALCULATION OF FOCALIZATION AND MAGNETIC SEPARATION OF HYDROGEN ATOMS. Audoin, C.; Desaintfuscien, M.; Schermann, J. P. (Faculte des Sciences, Orsay, France). Nucl. Instrum. Methods, 69: 1-10(Mar. 1969).

The phase-space method is used for the calculation of the beam intensity of neutral particles, when a force proportional to the distance from the beam-symmetry axis is applied. The focalization and the separation of hydrogen atoms according to their hyperfine levels, by means of a hexapolar magnet are discussed in detail. The effect of the diaphragms on the beam intensity is shown. Also, the velocity-selection properties of the system are demonstrated. Several examples are given. (auth)

**18424** APPROXIMATE ANALYTICAL SOLUTIONS OF THE THOMAS-FERMI EQUATION FOR POSITIVE IONS. Csavinszky, P. (TRW Systems, Redondo Beach, Calif.). J. Chem. Phys., 50: 1176-81(Feb. 1, 1969).

Approximate analytical solutions of the Thomas-Fermi (TF) differential equation for positive ions are obtained in two different forms. In the Sommerfeld-type approximation the solution is expressed as $\phi_S = \phi_0(1 + \eta_S)$, and in the Fermi-type approximation as $\phi_F = \phi_0 + \eta_F$. The function $\phi_0$ is an approximate analytical solution of the TF equation for neutral atoms, obtained previously by making use of a variational principle, and the functions $\eta_S$ and $\eta_F$ are determined by an iterative solution of second-order ordinary linear differential equations with the boundary and subsidiary (normalization) conditions of the TF theory of positive ions. The approximate solutions $\phi_S$ and $\phi_F$ are tested by calculating the second ionization energies of Ne, Ar, Kr, Xe, and Rn. The calculated values are found in better agreement with the experimental values than those obtained from the exact solution of the TF equation for ions. The reason for this is explained. (auth)

**18425** ROTATIONAL TEMPERATURE OF THE $N_2^+$ FIRST NEGATIVE SYSTEM EXCITED BY LOW-ENERGY ELECTRONS. Moore, John H. Jr.; Doering, John P. (John Hopkins Univ., Baltimore). J. Chem. Phys., 50: 1487-8(Feb. 1, 1969).

An apparatus that included a liquid-nitrogen-cooled collision chamber was used to obtain spectra of the (0,0) band (λ 3914 Å) of the $N_2^+$ first negative system excited by 30- to 300-eV electrons. Rotational temperatures as a function of electron energy for collision-chamber pressures of 2 and 6 μ Hg are presented. It is concluded that there is essentially no deviation of the rotational temperature from the ambient temperature in this energy range. (A.G.W.)

**18426** ATOMIC SCATTERING FACTORS FOR HEAVY ATOMS. Ogasawara, Makoto; Konaka, Shigehiro; Kimura, Masao (Hokkaido Univ., Sapporo). J. Chem. Phys., 50: 1488-9(Feb. 1, 1969).

The complex atomic scattering factors $|f(\theta)|$ and $\eta(\theta)$ were calculated for uranium by the WKBJ method. The results are compared with previous approximate calculations in terms of the modified Bessel functions ($K_0$ approximation) and with values calculated by Peacher and Wills [J. Chem. Phys., 46: 4809(1967)] by a numerical integration method. The WKBJ method and the numerical integration method yielded results in very good agreement with each other. Results obtained by the $K_0$ approximation differed by only 1 to 2% except at large scattering angles. (A.G.W.)

**18427** ELECTRON DETACHMENT FROM NEGATIVE OXYGEN IONS AT BEAM ENERGIES IN THE RANGE 3 TO 100 eV. Roche, A. E.; Goodyear, C. C. (Univ. of Liverpool). J. Phys., B (London), 2: 191-201(Feb. 1969).

Cross sections for the detachment of electrons from negative oxygen ions ($O^-$ and $O_2^-$) in oxygen and other target gases were obtained for incident ion energies in the range 3 to 100 eV. A single-collision beam technique was employed, and a new method devised for the separation of detached electrons from other charged collision products. The results are compared with the data of other workers, where available, and show good agreement. Evidence for associative detaching reactions involving $O^-$ in CO and $H_2$ was also looked for, and the results suggest an upper limit for these cross sections of the order of $10^{-17}$ cm$^2$ at an incident-ion energy of 5 eV. (auth) (UK)

**18428** FORMATION AND STUDY OF THE PROPERTIES OF HIGH-ENERGY MOLECULAR BEAMS OBTAINED FROM TRIATOMIC IONS OF HYDROGEN, DEUTERIUM, AND NITROGEN. Devienne, F. Marcel (Laboratoire de Physique Moleculaire des Hautes Energies, Peymeinade, France). Entropie, No. 24, 35-50(Nov.-Dec. 1968). (In French).

A study is made of the formation and some properties of triatomic molecules of hydrogen, deuterium, and nitrogen. After it is shown that formation of triatomic molecular beams from beams of triatomic ions by charge exchange is possible, certain properties of these molecular beams are analyzed. The properties of such neutral beams are different, at an energy E, from what they would be if the molecular beams were composed either of monatomic molecules of energy E/3 or of monatomic and diatomic molecules of respective energies E/3 and 2E/3. The main properties studied are the secondary electron emission rate on different metals, accommodation coefficients and gains of either zinc sulfide or organic crystal photoscintillators. Finally the possibility of detecting, by means of other devices, the triatomic ions formed by ionization of these molecular beams is pointed out. (auth)

**18429** LIGHT EMISSION IN VACUUM ULTRAVIOLET DURING ELECTRON INTERACTION IN GASES. PART A. INVESTI-

GATIONS IN OXYGEN. Sroka, W. (Univ., Hamburg). Z. Naturforsch., 23a: 2004-13(Dec. 1968). (In German).

A nearly monochromatic electron beam of low energy (0 to 200 eV) interacts with molecules of a gas ($O_2$, $N_2$, etc.). The radiation emitted in this collision process is observed with a vacuum monochromator. The registered wave length can be attributed to known transitions. The excitation functions and the appearance potentials of these processes are measured. It is found that the electrons dissociate the molecules in a single collision into excited atoms or ions, which emit a radiation in the vacuum ultraviolet. Furthermore it is shown that the above-mentioned processes also appear in low-current corona discharges and in non-self-sustaining discharges in the homogeneous electric field. The origin of the so-called gas-ionizing radiation is found to be a dissociation process combined with an excitation of the dissociation products. (auth)

**18430** CHEMICAL REACTION KINEMATICS. VIII. CROSS SECTIONS OF SOME D-ATOM TRANSFER REACTIONS IN THE ENERGY RANGE 1 TO 100eV. Hyatt, D.; Lacmann, K. (Hahn-Meitner-Institut fuer Kernforschung, Berlin). Z. Naturforsch., 23a: 2080-3(Dec. 1968).

A Bendix time-of-flight mass spectrometer has been modified to enable the determination of some ion–molecule reaction cross sections in the energy range 1 to 100 eV. In the reactions studied, $X^+ + D_2 \rightarrow XD^+ + D$ where X may be Ar, $N_2$, or CO, the results obtained agree with the predictions of the polarization theory in the range below 10 eV despite the fact that no intermediate complex is formed at these energies. Between about 10 and 50 eV where spectator stripping occurs, the cross section follows an approximate $E^{-1}$ dependence. Above these energies the results are consistent with a transition to a region in which knock-on processes predominate and where an impulse approximation treatment would be valid. (auth)

**18431** CHEMICAL REACTION KINEMATICS. IX. DEVIATION OF STRIPPING MODEL FOR REACTIONS $X^+ + D_2 \rightarrow XD^+ + D$ and $X^+ + CD_4 \rightarrow XD^+ + CD_3$. Ding, A.; Henglein, A.; Hyatt, D.; Lacmann, K. (Hahn-Meitner-Institut fuer Kernforschung, Berlin). Z. Naturforsch., 23a: 2084-90(Dec. 1968). (In German).

The velocity spectra and cross sections of reactions of the type $X^+ + D_2 \rightarrow XD^+ + D$ ($X^+ = Ar^+$, $N_2^+$, $CO^+$) have been found to be independent of the temperature of the target gas (–190° to 20°C). The additional forward scattering (as compared to spectator stripping) of the product ion at high energies cannot be explained by the thermal motion of the $D_2$ molecules. A recoil stripping mechanism is proposed. At low energies, an intermediate $XD_2^+$ is postulated that lives less than half a period of rotation and is forward scattered but quickly equilibrates the excess energy among the vibrational degrees of freedom. The reactions of $Ar^+$ and $N_2^+$ with $CD_4$ can be well understood by the stripping model over a wide range of energy. At low energies, no preferential forward scattering of the product ion is found as in the corresponding reactions with $D_2$. The strongly unsymmetric broadening of the product-ion band, and a small shift to lower velocities indicate a strong interaction of the incident ion with the $CD_3$ group at low energies. The formation of an intermediate complex $XCD_4^+$, which isotropically decays, is expected at energies of a few tenths of one eV. Direct measurements at such low primary-ion energies have not yet been possible. (auth)

**18432** RANGE OF VALIDITY OF STATIC POTENTIAL APPROXIMATION IN LOW-ENERGY ELECTRON SCATTERING CHECKED BY CROSS SECTION MEASUREMENTS OF Hg BETWEEN 25 AND 150eV. Eitel, W.; Jost, K.; Kessler, J. (Univ., Karlsruhe, Ger.). Z. Naturforsch., 23a: 2122-3(Dec. 1968).

A crossed-beam method was used to measure differential cross sections for electron elastic scattering by Hg between 25 and 150 eV. Results are compared with calculations based on the assumption that scattering takes place in the static (relativistic Hartree) potential of the atom. It is concluded that discrepancies between theory and experiment begin to become significant below about 70 eV. Exchange and correlation effects due to electron spin and charge polarization of the atomic electron cloud probably are the cause of these discrepancies. (A.G.W.)

**18433** MULTIATOMIC CLUSTERS EMERGING FROM A METAL SURFACE UNDER ION BOMBARDMENT. Hortig, G.; Mueller, M. (Max-Planck-Institut fuer Kernphysik, Heidelberg). Z. Phys., 221: 119-21(1969).

$[Ag_n]^-$ ions emerging from a silver target under bombardment with energetic krypton ions have been measured for n ranging up to 60. The relative intensities of ions with odd numbers are strikingly favored. The numbers n = 8 and 20 mark minima in the abundance of ions with even numbers. The observations are briefly discussed. (auth)

**18434** IONIZATION CROSS-SECTION OF AN ATOM BY DE-EXCITATION OF ANOTHER METASTABLE ATOM THROUGH COLLISION. Mori, Masatake (Tokyo Univ.). J. Phys. Soc. Jap., 26: 773-6(Mar. 1969).

A method for calculation of the ionization cross section of an atom by de-excitation of another metastable atom through collision (Penning ionization cross section) is proposed. The perturbed stationary-state method is applied and Jeffreys' approximation is used for the determination of the phase shift. Fano's formula is applied to the coupling between the discrete state and the continuum and a parameter $\beta$ is introduced by which the wave function is made to satisfy the initial condition. The method is applied to a long-range interaction $V = -C_n/R^n$. The velocity dependence obtained is the same as that of the previous work. The cross section in the case of n = 3 is about half the value obtained by the impact-parameter method. (auth)

**18435** ELEMENTARY QUANTUM CHEMISTRY. Pilar, Frank L. New York, McGraw-Hill Book Company, 1968. 733p. $15.50.

This text on the quantum theory of atomic and molecular electronic structure includes chapters on the following: origins of the quantum theory, elements of modern wave mechanics, operators and uncertainty relations, wave mechanics of some simple systems, kinetics of radiative processes, angular momentum in quantum mechanics, systems with spherically symmetric potentials, the many-electron atom, matrix theory, methods of approximating solutions to the Schroedinger wave equation, electron spin and the Pauli principle, elements of atomic structure, the Hartree–Fock self-consistent-field method, elements of group theory, molecular structure, electronic structure of diatomic and linear polyatomic molecules, electronic structure of nonlinear polyatomic molecules, naive treatments of pi-electron systems, and refined treatments of pi-electron systems. (A.G.W.)

**18436** PROOF OF THE EXISTENCE OF TRIATOMIC MOLECULES IN A MOLECULAR JET OBTAINED BY CHARGE EXCHANGE WITH A BEAM OF HYDROGEN TRIATOMIC IONS. Devienne, F.-Marcel (Laboratoire de Physique Moleculaire des Hautes Energies, Peymeinade, France). Compt. Rend., Ser. A, B, 267: 1279-81(Dec. 4, 1968). (In French).

The production of hydrogen triatomic ions from a neutral molecular beam obtained by charge exchange with $H_3^+$ is shown by means of two experimental arrangements. It is proven that such ions cannot be formed from molecular beams of monatomic and diatomic hydrogen. Only the existence of $H_3^+$ permits these results to be explained. (tr-auth)

**18437** ON THE EXPERIMENTAL DETERMINATION OF THE MAXIMUM RANGE OF MONOENERGETIC ELECTRONS. Tabata, Tatsuo; Ito, Rinsuke; Okabe, Shigeru (Radiation Center of Osaka Prefecture). Jap. J. Appl. Phys., 8: 393-8(Mar. 1969).

Tails of the absorption curves of monoenergetic electrons were measured under various measuring geometries for absorbers of Be, Al, Cu, Ag, and Au at an energy of 15 MeV, and for Al also at 4.1 and 9.8 MeV. The absorber was placed in air and transmitted electrons were detected by an ionization chamber. The curves were analyzed by the nth-power method to obtain the maximum range. The resulting values were found to be affected by the geometry, especially in the case of absorbers of high atomic number. It was also found that the tail decays exponentially in the case of the curve for Au at the smallest distance between the absorber and the detector. These facts invalidate general use for monoenergetic electrons of the definition of the maximum range given by the nth-power method, and a new definition with associated measuring procedure is proposed. (auth)

**18438** APPROXIMATE SEPARATION OF THE SCHROEDINGER EQUATION. Naray-Szabo, G. (Univ. for Technical Sciences, Budapest). Phys. Lett., 28A: 598(Feb. 10, 1969).

Approximating the charge density with one-electron position probability densities in an atom or molecule makes the Schroedinger equation separable. (auth)

**18439** THEORY OF THE KAPITZA–DIRAC EFFECT. Ezawa, Hiroshi (Gakushuin Univ., Tokyo); Namaizawa, Hiroshi. J. Phys. Soc. Jap., 26: 458-68(Feb. 1969).

The Kapitza–Dirac effect is the scattering of electrons by a standing wave of very intense light, which can be realized by using a laser beam. A theory is presented, in which no assumptions are necessary as to the strength of the field and to the length of the interaction time. The assumption that the laser beam should have a gentle cross-sectional profile is basic. It allows one to separate the electron motion into two components: The one parallel to the beam is the motion in the periodic field of light, which generates

"adiabatic potential" for the motion transverse to the beam. This picture can be compared to that of a hydrogen molecule in which electron motion generates the adiabatic potential for nuclear vibration. In this way, it is shown that the problem can be reduced to that of one-dimensional scattering. The present theory is shown to embrace the predecessor theories of Bartell and of Fedorov. (auth)

**18440** PARTICLES AND THEIR INTERACTIONS. Powles, J. G. London, Addison-Wesley, 1968. 272p. 47s.

The subject is treated under the following main headings: introduction; atoms, the first particles; size of atoms and molecules; forces between atoms and molecules; dynamics of particles; dynamics of particles in electromagnetic fields; collisions of particles; particles at high velocity — relativity; nature of space and time; many particles — probability and statistics; distribution of particles on energy levels; second law of thermodynamics; the partition function; nonclassical distributions; strongly interacting particles; laboratory experiments. (UK)

**18441** TEMPERATURE EFFECT ON THE TWO-GAMMA ANNIHILATION OF POSITRONS IN BISMUTH. Faraci, G.; Quercia, I. F.; Smaconi, M.; Turrisi, E. (Univ., Catania, Italy). Nuovo Cim., 60B: 228-38(Mar. 11, 1969).

Angular-distribution measurements were made of the two gammas produced by annihilation of positrons in a Bi single crystal and in a Bi polycrystal, at three temperatures: 300°K, 77°K, and 4.2°K. Measurements show that the area of the angular distribution curve decreases as the temperature of the single crystal is lowered. The observed decrease is 21% between 300°K and 77°K and 28% between 300°K and 4.2°K. No temperature effect has been detected with the Bi polycrystal. The results obtained with the Bi single crystal agree with those of Dekhtyar and Mikhalenkov; however observation of the annihilation spectra performed in the measurements excludes the interpretation of the effect given by these authors. A model is suggested by which the effect could be explained in terms of a collective-excitation mode. (auth)

**18442** MODEL HIDDEN-VARIABLE THEORY FOR HYDROGEN. Leiter, D. (Boston Coll.). Nuovo Cim., 60B: 107-13 (Mar. 11, 1969).

Solutions to a heuristic model for wave-mechanical hydrogen in which an ad hoc "hidden-variable" field $\lambda\pi(x,t)$ is added into the conventional Schrödinger equation are discussed. The resulting equation is nonlinear in $\psi(x,t)$ and has limit cyclic solutions that correspond to the conventional hydrogenic eigenfunctions. However, superpositions of eigenfunctions have the property that they collapse into pure eigenfunctions in a time $\tau_{LCT}$, which can be arbitrarily adjusted according to the value of $\lambda$. The relationship of the model to that of the "reduction of the wave packet" is discussed. (auth)

**18443** INTERPRETATION OF ISOTOPES SHIFTS IN NEODYMIUM. King, W. H. (Univ. of Newcastle upon Tyne, Eng.). J. Phys., B (London), 2: 268-70(Feb. 1969).

Isotope shifts in neodymium spectra were measured and interpreted by Gerstenkorn and Helbert (1968). An alternative interpretation of their measurements is given. This interpretation gives more reasonable values for the sizes of the deformation shifts. An interesting conclusion is that the volume of $^{150}$Nd is less than that of $^{146}$Nd. (auth)

**18444** ISOTOPE SHIFT MEASUREMENTS IN THE SPECTRUM OF TREBLY IONIZED CERIUM (Ce IV). Edwin, R. P.; King, W. H. (Univ. of Newcastle upon Tyne, Eng.). J. Phys., B (London), 2: 260-7(Feb. 1969).

Isotope shifts were measured between $^{140}$Ce and $^{142}$Ce in two lines of Ce IV using a Fabry–Pérot interferometer and a hollow cathode source. The results were: $\lambda$2457 Å ($6s\ ^2S_{\frac{1}{2}} - 6p\ ^2P_{\frac{1}{2}}$) 97 ± 3 mK, and $\lambda$ 2778 Å ($6s\ ^2S_{\frac{1}{2}} - 6p\ ^2P_{\frac{3}{2}}$) 100 ± 3 mK. The isotope shift constant was estimated to be 144 ± 6 mK. Of this, only 24 mK is caused by the change in deformation; this shift caused by a genuine increase in nuclear size has the unusually large value of 120 mK. The light source developed for this work should be suitable for the measurement of hyperfine structure in other highly ionized spectra. The fourth spectrum was obtained by pulsing the dc excitation voltage to the source. A table of isotope-shift data for elements from Sr to Ce is discussed. (auth) (UK)

**18445** STUDY OF THE WEAK LINES IN THE L EMISSION SPECTRUM OF SAMARIUM. Gokhale, B. G.; Shukla, S. N. (Lucknow Univ., India). J. Phys., B (London), 2: 282-5(Feb. 1969).

The L-emission spectrum of samarium was studied photographically using a 40-cm curved crystal transmission (Cauchois-type) spectrograph. A new quadrupole line at 1626.8 x.u. was observed for the first time and ascribed to the transition $L_I N_{IV,V}$ ($\gamma_{11}$). The presence of two more lines ($L_{II}N_{VI,VII}$, $L_{III}N_{VI,VII}$), observed by Deodhar and Karnatak in 1955, was confirmed. The measurements of the previously known dipole and quadrupole lines were compared with those of earlier workers. (auth) (UK)

**18446** ELECTRON-IMPACT IONIZATION CROSS SECTIONS AND IONIZATION RATE COEFFICIENTS FOR ATOMS AND IONS FROM SCANDIUM TO ZINC. Lotz, Wolfgang (Institut fuer Plasmaphysik, Garching, Ger.). Z. Phys., 220: 466-72(1969).

The empirical formula recently proposed was used to calculate electron-impact ionization cross sections for single ionization from the ground state for free atoms and for nearly all ionization stages from scandium (Z = 21) to zinc (Z = 30). For these species ionization rate coefficients are given under the assumption of a Maxwellian distribution of the impacting electrons. Multiple ionization, lowering of ionization potential, or collision limit are not taken into account. (auth)

**18447** ASYMPTOTIC EXPRESSIONS FOR CROSS SECTIONS FOR THE EXCITATION OF H ATOMS IN 2s OR 2p STATES BY FAST PROTONS. Khandelwal, G. S.; Choi, B.-H. (Univ. of North Carolina, Chapel Hill). J. Phys., B (London), 2: 308-(Feb. 1969).

Asymptotic expressions to order $1/v^2$ for cross sections for excitation by fast protons of H atoms in 2s or 2p states to any state n are obtained in the Born approximation. Good agreement with the exact results was found for impact energies equal to or greater than 25 keV. (auth) (UK)

**18448** CHARGE DISTRIBUTIONS OF LITHIUM IONS AFTER THEIR PASSAGE THROUGH MATTER. Wendt, M.; Hartung, J. (Univ., Jena, Ger.). Z. Naturforsch., 23a: 2019-22(Dec. 1968). (In German).

Charge distributions of lithium ions after passage through different gas and foil strippers are measured in the energy range between 0.5 and 2 MeV. The ratios of the equilibrated beam components with charge i and k ($F_{i\infty}/F_{k\infty}$) were found to obey simple power laws. A density effect of about 15% was observed. Measured charge distributions are compared with calculated. Relatively good agreement could only be reached with the method of Dmitriev using shell-dependent probability functions of Heckman. An empirical expression for the average equilibrium charge q as function of the particle energy is given and discussed. (auth)

**18449** REFRACTION AND REFLECTION OF FAST ELECTRONS BY THIN FOILS. Zeidl, H.; Baier, H. (Reaktorzentrum, Seibersdorf, Austria). Z. Naturforsch., 23a: 1988-94 (Dec. 1968). (In German).

The Monte Carlo method was applied to investigate the penetration of fast electrons through thin foils of matter. The "step by step method" was used. Energy loss and secondary electron emission were taken into account. As an example for the possible application of the computational program "refraction" and "reflection" of relativistic electrons on thin Al foils were calculated. Scattering and reflection depends significantly on the energy loss of the electrons in the foil. The "mean scattering angle" of the electron beam (with respect to the foil normal) has been shown to be smaller than the angle of incidence (with respect to the foil normal). Possible experimental methods to test the predictions on mean scattering and reflection angles are discussed. (auth)

**18450** MESOATOMIC PROCESSES AND A MODEL FOR LARGE MESOMOLECULES. Gershtein, S. S.; Petrukhin, V. I.; Ponomarev, L. I.; Prokoshkin, Yu. D. (Joint Inst. for Nuclear Research, Dubna, USSR. Inst. for High Energy Physics, Serpukhov, USSR). Usp. Fiz. Nauk., 97: 3-36(Jan. 1969). In Russian).

Processes occurring during the stoppage of negatively charged mesons in matter are studied because meson–atomic and meson–molecular processes affect greatly the subsequent stages of the capture process and allow the study of the effect of chemical bond on capture probability of $\pi^-$ mesons. Recent experiments indicated that there is a strong correlation between the slowing-down process and the nuclear absorption mechanism of negative mesons and the chemical structure because capture at excited meson–atomic or meson–molecular levels often involves energy transfer to the valence-shell electrons. Analysis of the change from the continuous to the discrete spectrum of mesons revealed that some of the mesons are first captured at high levels that belong not to individual atoms but to the molecule. A model was proposed, clarifying the decrease of the capture probability, W, of $\pi^-$ mesons by hydrogen in $Z_mH_n$-type compounds, whereby W is about $Z^{-3}$. Study of the charge transfer of $\pi^-$ mesons in hydrogen-containing compounds makes it possible to distinguish between chemically bound and free hydrogen; this is of interest for chemical kinetics. (49 references) (TTT)

**18451** ON THE FORMATION OF $(dd\mu)^+$, A MESONIC MOLECULAR ION. Vesman, E. Tr. Inst. Fiz. Astron., Akad. Nauk Est. SSR, No. 33, 88-93(1967). (In Russian).

There is a discrepancy between the calculations and the experimental data on the rate of the fusion reaction in $(dd\mu)^+$. This discrepancy is due to the excited state of $(dd\mu)^+$ with K = 1, v = 1. A rough estimation gives the binding energy $E_1 \approx -7$ eV for this state. If this state has the binding energy $E_1 \lesssim -4.6$ eV, the formation of $(dd\mu)^+$ associated with the dissociation of a deuterium molecule is possible. The rate of the formation of $(dd\mu)^+$ by this mode is found to be $\lambda_{dd} \lesssim 10^2$ sec$^{-1}$. If this state has the binding energy $E_1 \approx -16$ eV, $\lambda_{dd} \approx 10^8$ sec$^{-1}$. (auth)

## Cosmic Radiation

*Refer also to abstracts 17788, 17797, 18334, 18785, 18797, and 18870.*

**18452** (CONF-671217) PROCEEDINGS OF THE TENTH SYMPOSIUM ON COSMIC RAYS, ELEMENTARY PARTICLE PHYSICS AND ASTROPHYSICS, ALIGARH, DECEMBER 12-16, 1967. (Department of Atomic Energy, Bombay (India). Cosmic Ray Committee). 1967. 701p. Dep.

Separate abstracts were prepared for the 7 individual sections. (M.O.W.)

*For abstracts of individual sections see: 18289, 18453-18456, 18795, and 18823.*

**18453** (CONF-671217-, pp 1-100) COSMIC RAYS: PRIMARY COSMIC RADIATION. (Department of Atomic Energy, Bombay (India). Cosmic Ray Committee).

Approximately ten papers are presented on nuclei production in primary cosmic radiation. Other papers are presented that deal with general characteristics and detection methods for primary radiations. (M.O.W.)

**18454** (CONF-671217-, pp 101-64) COSMIC RAYS: COSMIC RAYS AS PROBES TO STUDY INTERPLANETARY CONDITIONS. (Department of Atomic Energy, Bombay (India). Cosmic Ray Committee).

Twelve papers dealing with variations in cosmic radiation are presented. (M.O.W.)

**18455** (CONF-671217-, pp 165-223) COSMIC RAYS: EXTENSIVE AIR SHOWERS AND MUONS. (Department of Atomic Energy, Bombay (India). Cosmic Ray Committee).

Nine papers are presented on various extensive air shower and muon measurements. (M.O.W.)

**18456** (CONF-671217-, pp 224-86) ASTROPHYSICS: ELECTRONS, X RAYS, AND GAMMA RAYS. (Department of Atomic Energy, Bombay (India). Cosmic Ray Committee).

The following papers are presented: (1) x-ray astronomy, (2) cosmic electrons, (3) cosmic-ray electrons in the galaxy, (4) electrons in metagalaxy and their implications, (5) isotropic background cosmic x-rays and upper limits for solar x-ray flux, (6) proposed experiments to measure the spectra and time variation of x-ray sources, and (7) the 0.5-MeV gamma flux at balloon altitudes over 7.6°N geomagnetic latitude. (M.O.W.)

**18457** (N-68-21341) ON THE RELATIONSHIP BETWEEN RECENT MEASUREMENTS OF COSMIC RAY ELECTRONS, NONTHERMAL RADIO EMISSION FROM THE GALAXY, AND THE SOLAR MODULATION OF COSMIC RAYS. Webber, W. R. (Adelaide Univ. (Australia). Dept. of Physics). Jan. 1968. Contract NsG-281-62. 79p. (NASA-CR-94108). CFSTI.

Utilizing recent measurements of the cosmic-ray electron spectrum at the Earth and the effects of solar modulation on this spectrum possible limits on the local interstellar electron spectrum were determined. Synchrotron emission from these interstellar electrons is then compared with the local (disk) volume emissivity of nonthermal radio emission as deduced from a study of radio-intensity profiles along the galactic equator. The detailed spectrum and magnitude of radio emissivity can be reproduced from the electron spectrum only for very stringent conditions on the magnitude of the local interstellar magnetic field, and the amount of solar modulation of cosmic rays. If the local interstellar electron spectrum which best reproduces the spectrum of local radio emissivity is compared with the electrons expected as secondaries from cosmic-ray collisions in the Galaxy, it is found that most electrons ≲300 MeV may originate via the secondary mechanism. (auth) (STAR)

**18458** (N-68-31415) DAY TO DAY VARIABILITY OF THE DAILY VARIATION OF COSMIC RAYS DURING THE QUIET PERIOD OF THE SOLAR ACTIVITY. Pak, Byung-So (Uppsala Univ. (Sweden)). Apr. 1968. 29p. CFSTI.

Calculation of the day-to-day variability of the daily variation of the cosmic-ray intensity using high-latitude neutron-monitor data is described. Variances of time of maxima, minima, and their differences were calculated for each solar rotation period, by superimposing first and second harmonics, as well as by smoothing the values. Several factors which may affect the analysis have also been discussed. A considerable correlation was found between the variances of maxima and minima and the solar activity expressed in Zürich relative sunspot number. This was not revealed by long-time averaged analyses. A negative correlation between the variances and averaged amplitudes over the period also appeared from the study. It was concluded that the daily variation may be characterized as follows: (a) the Axford-Parker theory on the daily variation is consistent with the observations on some days; (b) an azimuthal streaming could not manifest itself as a daily variation in the counting rate of the detectors, or the present analytical method is not sufficient to decide these physical quantities; (c) a separate mechanism responsible for the time of minimum would be operating on some days and independent of the time of maximum, so the daily variation of the cosmic-ray intensity can not be approximated by a diurnal variation. (auth) (STAR)

**18459** (SC-T-69-1009) CORRELATED NEUTRONS IN A SIMPSON PILE. Meyer, Bernhard. Translated by Marcel I. Weinreich (Sandia Labs., Albuquerque, N. Mex.), from Korrelierte Neutronen im Simpson-Pile. 51p. Dep. CFSTI.

Thesis. Submitted to Univ. of Munich, Ger.

Two neutron counters (standard Simpson Pile) were used to measure the low-energy nucleon component of cosmic radiation, and for this purpose the correlation of the recorded evaporation neutrons was examined. By means of multiplication, there occur on the average 1.25 neutrons for the Munich apparatus, while the apparatus at the Zugspitze mountain showed 1.30 neutrons. The variance of this multiplication was determined at about 0.54. This, as well as the variance of the triggering nucleons distributed according to Poisson, determines a minimum standard deviation of the counting sum. The latter agrees with the standard deviation as ascertained by the comparison of hourly values of both halves of the apparatus. Consequently, it is not possible to demonstrate a contribution of apparatus fluctuations within a comparative space of one hour each. It becomes apparent that the fluctuation of the dead time considerably affects the counting precision for counting times of one day and longer. It is proposed to reduce the relative standard deviation by prolonging the dead time up to the order of magnitude of the diffusion time, i.e., from the customary 5 or 10 μsec up to about 200 μsec. In such a case, the multiplication is suppressed and, moreover, the influence of the dead time variation on the standard deviation becomes minimal. (auth)

**18460** HIGH-ENERGY GAMMA RAYS, COSMIC-RAY ELECTRONS, AND THE FAR-INFRARED BACKGROUND RADIATION. Shen, C. S. (Purdue Univ., Lafayette, Ind.). Phys. Rev. Lett., 22: 568-72(Mar. 17, 1969).

It is shown that the observed flux of galactic gamma rays, which is one order of magnitude higher than the theoretical value, can be explained if one assumes the recently detected far-infrared radiation to be galactic or universal. Effects of the infrared radiation on cosmic rays are discussed. (auth)

**18461** MEASUREMENTS OF COSMIC-RAY Li, Be, AND B NUCLEI IN THE ENERGY RANGE 100 MeV/n TO >22 BeV/n. von Rosenvinge, T. T.; Ormes, J. F.; Webber, W. R. (Univ. of Minnesota, Minneapolis). Astrophys. Space Sci., 3: 80-101(Jan. 1969).

New measurements are reported of the spectra of Li, Be, and B nuclei in the primary cosmic radiation in the energy range 100 MeV/n to >22 BeV/n. The differential spectrum of these light nuclei is found to have a maximum at ~400 MeV/n in 1966. The L/M ratio is found to be equal to 0.25 ± 0.01, constant over the entire energy range of the measurement. Atmospheric and solar modulation effects on the L nuclei and the L/M ratio are discussed. It is concluded that this ratio is representative of conditions in interstellar space. Using the most recently available fragmentation parameters gives a material path length of 3.6 g/cm$^2$ of hydrogen for the particles producing the L nuclei. The absence of any variation of the L/M ratio with energy places severe constraints on models for the propagation of cosmic rays. Models in which the material path length is a strong function of energy—or that exhibit an exponential path-length distribution for a fixed energy are incompatible with these results. An examination of the abundance ratios of the individual L nuclei separately reveals major discrepancies with the predictions of interstellar diffusion theory based on presently accepted fragmentation parameters. The constancy of the measured Li/M and B/M ratios with energy is not in accord with the large energy dependence of these ratios expected from the energy dependence of the fragmentation cross sections.

The low Li/M ratio and high B/M ratio to be expected if these nuclei are created at a much lower energy are also not found. This presents difficulties for theories which suggest that the passage through matter has occurred at low energies subsequently followed by considerable acceleration. The Be/M ratio in cosmic rays is anomalous in that it is ~40% larger than expected on the basis of the fragmentation cross sections. Evidence presented here on the isotopic composition of Be nuclei suggests that this discrepancy is due to an enhanced abundance of $^9$Be or $^{10}$Be in cosmic rays. This discrepancy complicates the determination of a cosmic-ray "age" using the decay of $^{10}$Be into B. Nevertheless the Be/B ratio is observed to remain constant at 0.42 ± 0.03 over the energy range from 100 MeV/n to over 10 BeV/n. Unless the fragmentation parameters into the various isotopes of Be and B are such that e.g., $\Delta$(Be/B) < 0.05 as a result of this decay, then the age of cosmic rays is either $>3 \times 10^8$ years or $< 10^6$ years. The further observation that the mass to charge ratio of all Be nuclei of energy ~1 BeV/n is = 2.05 ± 0.1 suggests that $^{10}$Be is present at these energies. This supports the idea of a short lifetime. (auth)

**18462** RELATIVE ENERGY SPECTRA OF CARBON AND OXYGEN NUCLEI IN THE PRIMARY COSMIC RADIATION. von Rosenvinge, T. T. (Univ. of Minnesota, Minneapolis); Webber, W. R.; Ormes, J. F. Astrophys. Space Sci., 3: 4-13(Jan. 1969).

Measurements of the energy spectra of carbon and oxygen nuclei in the primary cosmic radiation over the energy range from 140 MeV/n to 30 BeV/n are reported. An average C/O ratio of 1.11 ± 0.02 is obtained at the top of the atmosphere. This ratio is found to be constant to within ~5% over the entire energy range. The energy spectra of these two nuclei are presented and compared with earlier measurements and with satellite observations at low energies. After correction for propagational effects in 4 g/cm$^2$ of interstellar hydrogen the "source" C/O ratio is found to be ~0.9. The astrophysical implications of this C/O ratio are discussed. (auth)

**18463** POSSIBLE ORIGIN OF HIGH-ENERGY COSMIC GAMMA RAYS? Cowsik, R.; Pal, Yash (Tata Inst. of Fundamental Research, Bombay). Phys. Rev. Lett., 22: 550-1(Mar. 17, 1969).

The intensity of the new microwave radiation observed by Shivanandan, Houck, and Harwit is adequate to produce, by Compton scattering on cosmic-ray electrons, the flux and distribution of ~100-MeV $\gamma$ rays reported by Clark, Garmire, and Kraushaar. (auth)

**18464** PLANETARY DISTRIBUTION AND ENERGY BALANCE OF THE COSMIC LAYER IN THE LOWER IONOSPHERE. Velinov, Petar. Izv. Geofiz. Inst., Bulg. Akad. Nauk, 11: 87-102 (1967). (In Bulgarian).

The changes are considered in the electron production g(h) and the ionization capacity of the cosmic rays C(>R) with respect to the geomagnetic threshold of hardness R or its corresponding energies $E_i$ or the geomagnetic latitude $\lambda_m$. Expressions are deduced for (dg(h)/dR), (dC(>R)/dR), and (dC/d$\lambda_m$). The total electron production $Q_t = \int g(h)dh$ in a column with a section 1 cm$^2$ is examined. $Q_t$ is calculated in the cases of polytropic or isothermal atmosphere. It is shown that the ratio of the energy $J_D$ discharged in the ionosphere to the complete energy of the cosmic rays $J_{ka}$ depends on the geomagnetic threshold R or $\lambda_m$. The conclusion is drawn that the flux of energy $J_D$ is comparable to that of some atomic and nuclear processes with less energy in the atmosphere, caused by cosmic rays. For these reasons, the ionosphere does not play a role in the energy balance of the primary cosmic rays, whereas they, forming the lowest part of the ionosphere, exercise a considerable effect on the distribution of long waves and the absorption of short waves. (Abstr. of Bulg. Sci. Lit.)

**18465** MATTER TRAVERSAL OF HIGH-ENERGY PRIMARY COSMIC RAYS FROM ANTIPROTON MEASUREMENTS. Rosen, S. (Institut d'Astrophysique, Paris. CEN, Saclay, France. General Research Labs., Bayonne, N. J.). Nuovo Cim., Lett., 1: 336-9(Feb. 21, 1969).

The small portion of the primary proton component which has energies in excess of 5.6 GeV and, consequently, contains the predecessors of antiprotons is considered. The method of obtaining information on this component consists in measuring and analyzing the antiproton flux and energy in the primary galactic beam. (J.F.P.)

**18466** ELEVEN-YEAR VARIATIONS OF COSMIC-RAY INTENSITY AND HELIOLATITUDES OF SUNSPOTS. Kudo, Shoko; Wada, Masami (Inst. of Physical and Chemical Research, Tokyo). Rep. Ionosphere Space Res. Jap., 22: 137-47(1968).

In order to investigate the influence of solar activity on the eleven-year variation in cosmic-ray intensity, the heliolatitudinal movement of sunspot regions in a solar cycle is taken into account, in addition to the sunspot number which is the usual measure of solar activity. The negative correlation between the sunspot number and cosmic-ray intensity in an eleven-year variation is appreciably improved by adding a function of the heliolatitude of the sunspot region. The cosmic-ray intensity depends on the sunspot latitude in such a manner that the degree of the intensity depression is intensified monotonically as the sunspot region approaches the equator. The latitude dependence might be an evidence for the existence of a gradient in cosmic-ray density perpendicular to the ecliptic plane. The gradient is dependent on the heliolatitude and is proportional to the sunspot number. For the duration of the Mariner IV experiment, the value of the perpendicular gradient estimated from cosmic-ray intensity observed in high latitudes by means of a neutron monitor is 9 ± 1%/A.U. It is compared with the radial gradient; observations on Mariner IV showed 9.0 ± 1.5%/A.U. for charged particles of mean rigidity ~6 GV, and 6.8 ± 1.6%/A.U. for the ionizing component of threshold energy 10 MeV/nucleon. The perpendicular gradient also shows a rigidity dependence. (auth)

**18467** NUCLEAR INTERACTIONS AND COSMIC RADIATION AT ENERGIES AROUND $10^6$ GeV. McCusker, C. B. A.; Peak, L. S.; Rathgeber, M. H. (Univ. of Sydney). Phys. Rev., 177: 1902-20(Jan. 25, 1969).

The results of a series of Monte Carlo simulations of extensive air showers are compared with experimental data from the Sydney 64-scintillator array and other experiments. The work has had two main objectives: (a) the study of the composition of cosmic radiation around $10^6$ GeV; (b) the study of nuclear interactions at very high energies. In the first field, evidence is produced to show that the composition of cosmic radiation is much the same at $10^{15}$ eV total energy as at $5 \times 10^{10}$ eV total energy. Above about $3 \times 10^{15}$ eV the composition changes, the beam becoming progressively richer in heavier nuclei up to energies of about $10^{17}$ eV. In the second field, the main result reported is that at energies above $10^{14}$ eV there is evidence that much higher transverse momenta occur than at accelerator machine energies. If true, this implies that a force is acting which is much stronger than the normal strong interaction. (auth)

**18468** THE SPECTRUM OF HIGH-ENERGY $\gamma$ QUANTA AT AN ALTITUDE OF 3250 m ABOVE SEA LEVEL. Babayan, Kh. P.; Marutyan, N. A.; Mitoyan, S. V. (Inst. of Physics, Frevan). Izv. Akad. Nauk Arm. SSR, Ser. Fiz., 3: 196-9(1968). (In Russian).

The results are presented of a treatment of the experimental data obtained at an altitude of 3250 m above sea level (Mt. Aragats). The integral energy spectrum of $\gamma$ quanta in the energy range $10^{12}$ eV $\lesssim E \lesssim 10^{13}$ eV with an exponent $\alpha = 1.9 \pm 0.16$ and zenith angle distribution $dN/d\theta \sim (\cos\theta)^{5.5\pm0.5}$ is obtained. (auth)

**18469** SPECTRUM OF EXTENSIVE AIR SHOWER WITH RESPECT TO THE NUMBER OF THE PARTICLES AT MOUNTAIN ALTITUDE. Babayan, Kh. P.; Boyadzhyan, N. G.; Grigorov, N. L.; Davydova, L. S.; Nymmik, R. A.; Sarychev, L. I.; Sobinyakov, V. A.; Shestoperov, V. Ya. (Inst. of Physics, Erevan). Izv. Akad. Nauk Arm. SSR, Ser. Fiz., 3: 189-95(1968). (In Russian).

The results of the investigation on the spectrum of EAS with respect to the number of the particles at an altitude of 3200 m above sea level (Mt. Aragats) are given. The EAS spectrum measurement is performed with the help of an arrangement consisting of 10 scintillation counters with 0.25-m$^2$ area each, an ionization calorimeter with 10 m$^2$ working area, and some groups of Geiger–Mueller counters. The obtained integral EAS spectrum in the region of particle numbers $N \geq 1.6 \times 10^5$ has the form $F(\gg N) = (4.7 \pm 0.5) \times 10^{-2}\ (N/1.6 \cdot 10^5) - (1.5 \pm 0.2)$. The given EAS absolute intensity does not contradict the experimental data given by other authors obtained at altitudes of 3860 and 5200 m above sea level. (auth)

## Direct Energy Conversion

*Refer also to abstracts 18495, 18556, 18771, and 18859.*

**18470** (AD-672686) PARAMETERS OF MAGNETOHYDRODYNAMIC (MHD)-GENERATORS TAKING INTO ACCOUNT IONIZATION INSTABILITY OF PLASMA (INTRODUCTION). Gurashvili, V. A.; Kareev, Yu.; Nedospasov, A. V. Translated from pp 3-13 of Parametry MGD-Generatorov s Uchetom Ionizatsionnoi Neustoichivosti Plazmy, Moscow, 1967. 28p. (FTD-MT-24-205-67). CFSTI.

Calculations of MHD generators with unbalanced conductivity, taking into account ionization instability, are discussed. As a working medium, argon and mercury vapor containing addition of

cesium vapors are examined. Theory and experiment show that ionization instability is developed with such parameters of plasma which are assumed to be used in MHD generators with unbalanced conductivity. New approaches toward the selection of MHD generators are touched upon. (auth) (USGRDR)

**18471** (AD-672995) HALL EFFECT, ION SLIP, AND END EFFECTS IN FARADAY GENERATORS. Bresgen, Helmut; Falser, Helmut (Innsbruck Univ. (Austria). Institut fuer Theoretische Physik). Mar. 25, 1968. Contract F61052-67-C-0014. 30p. (AFOSR-68-1307). CFSTI.

The investigation of a Faraday-type generator is carried out under the assumption of low electrical conductivity. Therefore, the fluid and Maxwell equations can be decoupled, neglecting interaction between plasma and applied magnetic field. This leads to Laplacian equations for the stream and potential functions, which are solved by the method of Fourier series expansion, subject to mixed boundary conditions. The resultant infinite set of equations for the Fourier coefficients can be solved numerically to desired accuracy. Hall effect and ion slip are included. The first part starts from only one pair of electrodes and thus yields end effects resulting from a lengthening of the current lines in the plasma. In parts two and three generalizations for variable velocity profile, several pairs of electrodes, and also variable electrical conductivity are pointed out. In the last chapters the method is compared to other approaches and a numerical calculation of the internal resistance for several values of Hall parameter and aspect ratio of the generator duct is carried out. (auth) (USGRDR)

**18472** (BMwF-FBK-68-40) ENERGY CONVERSION BY MEANS OF AMORPHOUS INSULATING THIN FILMS. Hartl, M.; Mueller, R. G. (Technische Hochschule, Munich (West Germany). Institut fuer Technische Elektronik). Sept. 1968. 34p. (In German). Dep.

The conversion of radiation energy into electrical energy by means of a photovoltaic effect in sandwich-contacted amorphous insulating films (anodic $Ta_2O_5$, $Nb_2O_5$ and CdS) was investigated. Due to their amorphous structure, no radiation damage was expected. Technological problems of the preparation were studied. The quantum yield Q was investigated by irradiating with uv-light; Q has a maximum of approximately 30% in very thin films (~100 Å). The dependence on the intensity is linear. Q increases in temperature up to about 150°C. The necessary minimum thickness of the gold top electrode is 100 Å. Experiments as a function of the wavelength (including x rays) confirm that the investigated photoeffect is a bulk effect in the insulator. (auth)

**18473** (HASL-198) DETERMINING THE "STATE OF CHARGE" OF NICKEL-CADMIUM BATTERIES BY FARAD CAPACITANCE MEASUREMENTS. Latner, Norman (New York Operations Office (AEC), N. Y. Health and Safety Lab.). Aug. 1968. 33p. Dep. CFSTI.

A rapid simple method has been developed for determining the state of charge of the widely used nickel-cadmium rechargeable battery. The method described is based on the experimentally verified relationship between farad capacitance and state of charge. Using this relationship, a standard reference curve (capacitance vs. state of charge) was established based on repeated runs of a specific battery type. By measuring the capacitance of any battery of this type and matching it to its standard reference curve, the state of charge is quickly determined. Also presented are the initial investigations of open and closed circuit voltage measurements, impedance at one or more frequencies, battery voltage rise time and commercially available timer-chargers and coulometers; all of which proved inadequate as a means of determining state of charge. (auth)

**18474** (UCRL-50537) ONE-DIMENSIONAL CALCULATIONS ON A FINITE-LENGTH MHD INDUCTION CONVERTER. Heusinkveld, Myron (California Univ., Livermore. Lawrence Radiation Lab.). Oct. 30, 1968. 71p. Dep. CFSTI.

A linear induction converter is considered here, involving the flow of a liquid metal, through a narrow channel across which an ac magnetic field is impressed. Electrical currents are induced in the fluid, which react back on the field windings to generate electrical power. The magnetic field relations are solved in the one-dimensional approximation, in which the magnetic field and the fluid velocity are uniform across the gap. The equation for the total magnetic induction $B_t$ is deduced from Faraday's law. The solution of this equation is found. The quantities $B_t(0)$ and $E_0$ (the potential gradient in the transverse direction) are evaluated by using the div $\vec{B} = 0$ and div $\vec{J} = 0$ requirements. This results in a final solution which depends only on the excitation current $\delta J_e$, which may have an arbitrary distribution along the length of the converter. From this solution, equations are obtained for electrical impedance of the excitation winding, hydrodynamic power input, real and reactive electrical power output, and the energy conversion efficiency. Predictions from this analysis are compared with experimental data from a linear converter model. Results of numerical calculations of the problem of a uniform traveling-wave generator of finite length are presented. These results include magnetic field distribution, electrical impedance, and conversion efficiency as a function of magnetic Reynolds number, generator slip, converter length in wavelengths, and end current. The case of the MHD converter in which the magnetic field varies both across the gap and in the downstream direction is then discussed and analyzed. The basic induction equation is deduced and solved in a manner similar to that of the one-dimensional case, giving a qualitative idea of the error incurred in the use of the one-dimensional approximation. (auth)

**18475** THERMOELECTRIC GENERATOR FOR SUPERCONDUCTING SOLENOIDS. Borzov, G. G.; Gol'tsman, B. M.; Ikonnikova, G. I.; Sergeev, V. P.; Shapiro, E. Kh. (Inst. of Semiconductors, Leningrad). Zh. Tekh. Fiz., 38: 1817-21(Oct. 1968). (In Russian).

The use of thermoelectric generators in which cold junctions of thermocouples are cooled by liquid nitrogen and hot junctions are maintained at 40 to 80°C with heaters, for supplying power to superconducting solenoids is discussed. Thermoelectric generators have small dimensions and weight, and the principle of its operation excludes gradual changes in current. (tr-auth)

**18476** CLASSIFICATION OF THE OPERATING MODES OF HOT-CATHODE PARALLEL-PLANE PLASMA DIODES. Salinger, Sheldon; Rowe, J. E. (Univ. of Michigan, Ann Arbor). IEEE (Inst. Elec. Electron. Eng.) Trans. Educ., E-11: 182-94(Sept. 1968).

Plasma diodes with externally heated cathodes can operate in a number of different modes and several studies have been conducted in the past in an attempt to correlate the behavior of the various modes of operation. First the behavior of noble-gas-filled plasma diodes is considered. Even though the modes of Cs plasma diodes have been characterized rather completely, no comparable summary has been developed for noble-gas systems. The operation of hot-cathode parallel-plane plasma diodes is reviewed and the characteristics of the anode-glow, ball-of-fire, Langmuir, temperature-limited, low-voltage arc, and tufted-anode modes are classified and discussed in terms of the volt-ampere characteristics for different load lines. The operation of noble-gas diodes is compared to that of Cs diodes and the interpretation of the volt-ampere characteristic is related to available experimental data. The visual characteristics of each mode are also displayed to aid in the interpretation of the behavior. The correlation between theory and a variety of experiments substantiates the contention that the limitation imposed on the diode current by the cathode is responsible for the previous confusion about the various modes of operation. (BBB)

**18477** THEORY OF ARC-MODE THERMIONIC-CONVERTER PERFORMANCE. Wagner, P. Siegfried (Univ., Rostock, Ger.). Energy Convers., 9: 39-40(Mar. 1969).

The principal behavior of the I-V characteristic of a Cs converter at Cs vapor pressures of several torr is shown. There are two ranges in the characteristics, the range for low currents with high resistivity, the so-called "extinguished mode" and the range for high currents, called "ignited mode." These designations are based on the idea that there exists an arc mechanism in the ignited mode and that there is also generation of additional carriers by nonthermal ionization phenomena. The transition to the "ignited mode" at ~0.8 V represents the ignition of the arc. This would mean that this arc starts at an effective voltage of 0.8 V, the difference between the voltage at zero current and at the transition point. A study of the energy level scheme of the cesium atoms shows that the lowest level lies at 1.4 V. Therefore, at 0.8 V it is not possible to obtain ionization by supplying the ionization energy in two or more steps. Nonthermal ionization is improbable. It is shown that the experimental characteristic can also be explained without nonthermal ionization. (auth) (UK)

**18478** CATHODIC POTENTIAL DROP OF THE COLD ELECTRODE OF MHD GENERATORS. Ogiwara, Hiroyasu (Tokyo Shibaura Electric Co., Ltd.). Jap. J. Appl. Phys., 8: 388-92(Mar. 1969). (In French).

Resistivity of the boundary layer in the MHD generator duct with water-cooled metal electrodes is considered to be the limiting factor of the MHD generating performance. The voltage-current characteristics were studied by using water-cooled, segmented electrodes. The high-resistivity parts of the characteristics were investigated with potential probes. Notable voltage drop was found both in front of the cathode and the anode. The voltage drop in front of the cathode seemed to be saturated beyond a certain value in the current, where thin arcs appeared on the

cathode surfaces. The voltage drop in this region is well explained by a theory of heat transfer under forced convection. (auth)

**18479** MAGNITOGIDRODINAMICHESKII METOD POLUCHENIYA ELEKTROENERGII. (Magnetohydrodynamic Method of Producing Electric Power). Kirillin, V. A.; Sheindlin, A. E. (eds.). Moscow, Energiya, 1968. 480p.

Construction problems and experimental investigations of power equipment are described in the first chapter. Thermal cycles and technological–economic aspects of power plants with MHD generators are discussed in the second chapter. The third, fourth, and fifth chapters cover the problems of plasma physics for MHD generators, MHD flow in channels, and liquid-metallic MHD installations. (R.V.J.)

**18480** THEORETICAL ANALYSIS OF A COAXIAL HALL ACCELERATOR. Lackner, Karl (Univ., Innsbruck). Z. Angew. Math. Phys., 19: 844-50(Nov. 25, 1968).

Theoretical performance studies for the coaxial Hall accelerator have been carried out previously. Here a detailed analysis of the possible operational regimes and a closed analytical solution for the variation of the plasma parameters with axial distance are given. (M.H.R.)

**18481** MHD: MAGNETOHYDRODYNAMIC POWER GENERATION. Petty, Stanley W. (Avco Everett Research Lab., Everett, Mass.). Cryog. Eng. News, 4: No. 3, 28; 30; 32; 34; 36(Mar. 1969).

The technical feasibility of MHD generators is discussed from the standpoint of ten years of experience with the development and construction of experimental devices. Primary emphasis is put on the feasibility of an emergency MHD peaking plant. Cost, performance, and design criteria are summarized for a full-sized MHD plant. (M.H.R.)

**18482** MERCURY VAPOR FOR MAGNETOHYDRODYNAMIC GENERATORS. Zauderer, Bert (to Secretary of the Air Force). U. S. Patent 3,430,081. Feb. 25, 1969. Filed Dec. 2, 1964.

A system for generating electrical power including a closed-loop nuclear reactor heating system; a closed loop MHD generator utilizing vapor seeded with barium and a heat exchanger connecting the two loops, whereby the nuclear reactor heats the mercury vapor working fluid of the generator. (Offic. Gaz.)

## Fluid Physics

**18483** (AD–672996) SIMILARITY SOLUTIONS FOR TWO-DIMENSIONAL STEADY VISCOUS MGD BOUNDARY LAYERS. Cap, Ferdinand; Floriani, Dietmar (Innsbruck Univ. (Austria). Institut fuer Theoretische Physik). May 20, 1968. Contract F61052-67-C-0014. 21p. (AFOSR–68-1326). CFSTI.

The equations for steady two-dimensional MGD flows (i) in boundary layer approximation, (ii) without approximation are solved. A magnetic field B perpendicular to the flow plane and constant but arbitrary viscosity, electrical and heat conductivity are assumed. First, all equations are written in a form free of parameters and then similarity transformations are applied. Via the transformed continuity equation, the new equations can be simplified for channel flows. If these similarity solutions enclose imcompressible flows, the solution for the velocity is for boundary layer approximation, given in a closed form. (auth) (STAR)

**18484** (AD–673292) ENERGY TRANSFER PROBLEMS IN SUPERCONDUCTORS AND FLOWING PLASMAS. Final Report. Akhurst, Denys O.; McCutcheon, Martin J.; Anderson, Melvin K. (Arkansas Univ., Fayetteville. Plasma Lab.). Oct. 1967. Contract DA-01-021-AMC-12820(Z). 259p. (UAPL–31). CFSTI.

Theoretical and experimental studies of energy storage and transfer in cryogenics and magnetohydrodynamics are described. In the cryogenic studies, electrical energy is stored in superconducting coils and extracted with a 98% energy transfer efficiency. Theoretical support is given for the switching, storage and extraction results. In the magnetohydrodynamic studies, electrical energy is extracted from the high temperature plasma flow through a dc MHD generator. Included in the study is a survey of dc and ac MHD Generators, an analysis of cylindrical ac MHD generators, and investigation of a pulsed induction ac MHD generator and the design and operation of a small scale dc MHD generator. (auth) (USGRDR)

**18485** ON THE MAGNETOHYDRODYNAMIC EQUATIONS GOVERNING THE FLOW OF A CONDUCTING FLUID IN THE PRESENCE OF A VERY HIGH MAGNETIC FIELD (WITH APPLICATION TO ADVANCED SYSTEMS OF PROPULSION). Nihoul, Jacques C. J. (Institut de Mathematique, Liege. Institut de Mecanique, Louvain, Belg.). Ann. Soc. Sci. Brux. Ser. I, 82: 431-6(Dec. 31, 1968).

The magnetohydrodynamic equations governing the flow of a conducting incompressible fluid in the presence of a very high magnetic field are established and discussed with a view on certain advanced propulsion systems. Several simple forms of these equations, pertinent to steady motion, are considered and referred to previous studies of classical fluid mechanics. (auth)

**18486** STEADY MAGNETOGASDYNAMIC FLOW IN FINITE REGIONS. Ragaller, K. (Technische Hochschule, Munich). Z. Naturforsch., 23a: 1940-52(Dec. 1968). (In German).

Steady, two-dimensional, magnetogasdynamic flows in a finite region are investigated. The case of aligned fields is treated. Outside of the flow a resting gas with arbitrary electrical conductivity is assumed. As the induced magnetic field can propagate throughout the resting gas, all the flow is strongly influenced by this adjacent field-occupied region. This interaction between the field in the resting ambient gas and the flow can be formulated as an integral equation, the solution of which is given. In a number of examples the applicability of this formalism is demonstrated. So the flow around a body, the reflection of waves at a boundary, and the influence of an applied magnetic field, are investigated for a flow in the halfspace and for a jet of finite thickness. Besides the flow variables, the location of the boundary and the induced field outside of the flow, are calculated. (auth)

**18487** EFFECT OF TENSOR CONDUCTIVITY ON COLLISIONLESS MAGNETOGASDYNAMIC FLOWS. Tang, J. Y. T.; Seebass, R. (Cornell Univ., Ithaca, N. Y.). Phys. Fluids, 12: 381-8(Feb. 1969).

Steady, linearized, aligned-fields flow of a collisionless plasma past slender bodies is investigated. An approach similar to that of Chew, Goldberger, and Low is used to derive a consistent set of hydrodynamic-like equations for treating collisionless magnetogasdynamic flows in the presence of a strong magnetic field. The nature of the behavior predicted by this system of equations, in contrast to the original Chew–Goldberger–Low system, is similar to that predicted by the continuum equations of Sears and Resler. For certain specialized upstream conditions these two systems are identical. The close mathematical relationship that exists between them provides a convenient interpretation of collisionless plasmadynamic phenomena in terms of continuum variables. (auth)

**18488** MAGNETOHYDRODYNAMIC FLOW IN A CONTAINER. Ingham, D. B. (Massachusetts Inst. of Tech., Cambridge). Phys. Fluids, 12: 389-96(Feb. 1969).

A linear theory for steady rotational motions is presented under the assumptions that $R_m$ and $\epsilon$ are much less than E where $R_m$, $\epsilon$, and E are the "rotational" magnetic Reynolds, Rossby, and Ekman numbers, respectively. The effect of the "rotational magnetic force coefficient," $N^2 (= \sigma\mu^2 H_0^2/\rho\Omega)$, which is a measure of the relative importance of the magnetic forces (of order $\sigma\mu^2 \Omega L H_0^2$) and the rotational forces (of order $\rho\Omega^2 L$) is investigated. Attention is focused on the case when the direction of rotation and applied magnetic field at infinity are parallel, and all boundaries are either perpendicular or parallel to this direction. If $N^2 \ll 1$, Ekman layer suction and the double structure of the vertical Stewartson layers are dominant, but if $N^2 \gg E^{-\frac{1}{3}}$, the magnetic forces dominate and a Hartmann-type boundary layer is present with the double structure of the vertical boundary layer disappearing and being replaced by a single layer. A solution for the complete range of values of $N^2$ is presented. (auth)

**18489** MAGNETOHYDRODYNAMIC FREE CONVECTION FROM A HORIZONTAL PLATE. Singh, S. N.; Cremers, C. J. (Univ. of Kentucky, Lexington). Phys. Fluids, 12: 379-80(Feb. 1969).

The solution for a more realistic free-convection problem from a horizontal plate under the action of a uniform vertical magnetic field is presented. (auth)

**18490** WEAK DISCONTINUITIES IN SHALLOW-LIQUID MAGNETOHYDRODYNAMICS. Kaul, C. N. (Indian Inst. of Tech., Kharagpur). J. Math. Anal. Appl., 25: 425-34(Feb. 1969).

Among other things, Fraenkel (J. Fluid. Mech., 7: 81-107(1960)) discussed the damping effect of the magnetic field on a plane surface of "weak discontinuity" to develop, under certain conditions, into a "strong discontinuity," considering only the one-dimensional unsteady case. A general cylindrical weak discontinuity is considered here in the two-dimensional unsteady case. It is first shown that two types (contact discontinuity and wave surface) are possible in shallow liquid magnetohydrodynamics. Later, an equation governing growth or decay of a wave surface advancing

in a "quiet" liquid is derived. It is shown that, in general, either the wave surface decays and is ultimately damped out, or it grows and terminates in a shock. In the case of a plane wave surface, however, it is possible to find a critical value of the initial discontinuity so that the wave propagates without growth or decay. For a general cylindrical wave surface with convex side toward the undisturbed fluid, there exists a critical value of the initial discontinuity for which the wave never completely decays out, but the discontinuity tends to a critical value as for the plane wave. In general, the presence of a magnetic field has a damping effect on the tendency of the wave surface to culminate in a shock, under certain conditions. (auth) (TSS)

**18491** DECAY OF A MAGNETOHYDRODYNAMIC SHOCK WAVE. Gundersen, Roy M. (Univ. of Wisconsin, Milwaukee). Z. Angew. Math. Phys., 19: 864-81(Nov. 25, 1968).

Linear analysis is used to study weak nonisentropic perturbations in equations relative to the one-dimensional, unsteady flow of an ideal, inviscid, perfectly conducting, compressible fluid subjected to a transverse magnetic field. The general solution for the nonisentropic perturbation of a simple centered wave is used to study the decay of a nonuniform shock wave as generated by considering the interaction of an initially uniform shock wave and a centered rarefaction wave. In the limiting case of vanishing field, the solution reduces to that of classic gas dynamics. (M.H.R.)

**18492** ANALYSIS OF TWO-DIMENSIONAL ALIGNED-FIELD MAGNETOGASDYNAMIC FLOWS. Kingston, John G.; Power, Geoffrey (Univ. of Nottingham, Eng.). Z. Angew. Math. Phys., 19: 851-63(Nov. 25, 1968).

An attempt is made to provide a more detailed and thorough analytical background to some aspects of the magnetogasdynamic problem. An inviscid finitely conducting fluid is assumed to move steadily and two-dimensionally. It is then found that the basic equations can be simplified to two sets of equations corresponding to two distinct regions of flow. It is shown that in regions where the electric charge density is non-zero, the magnetic field must be irrotational. In regions where the electric charge density is zero, the basic equations can be greatly simplified. A great deal of attention has been given to infinitely conducting fluid flows in which the velocity and magnetic fields are everywhere aligned. By employing a complex variable technique, this type of flow is analyzed for a finitely conducting fluid. This technique can also be applied to other types of flow fields. (M.H.R.)

**18493** THE FLUCTUATING FLOW OF A VISCOUS INCOMPRESSIBLE CONDUCTING FLUID PAST AN INFINITE FLAT PLATE WITH TIME DEPENDENT SUCTION IN THE PRESENCE OF A TRANSVERSE MAGNETIC FIELD. Mehta, K. N.; Radha Krishna, C. V. (Indian Inst. of Tech., New Delhi). Proc. Nat. Inst. Sci. India, Part A, 34: Suppl. I, 28-40(Sept. 1968).

Analytical solutions have been obtained for the momentum and energy equations of the fluctuating flow of a viscous, incompressible, and electrically conducting fluid past an infinite porous flat plate in the presence of a transverse magnetic field when the suction velocity fluctuates with the same frequency as that of the free stream but with a phase difference $\alpha$. It is observed that the effect of the magnetic field is to prevent the reverse flow which occurs at higher frequencies and moderately high amplitudes of the free stream velocity fluctuations. The mean wall temperature and heat flux are observed to be independent of the frequency in contrast to the case of constant suction velocity. (auth)

**18494** RAYLEIGH-TAYLOR INSTABILITY WITH HALL CURRENTS. Agrawal, S. C. (Indian Inst. of Tech., Kanpur). J. Phys. Soc. Jap., 26: 561-5(Feb. 1969).

The Rayleigh–Taylor instability problem is discussed for an inviscid heterogeneous and incompressible fluid of zero electrical resistivity in the presence of Hall currents. The external magnetic field is taken to be in the horizontal direction and uniform. It is shown that statically stable arrangement in the absence of magnetic field remains stable in the presence of Hall currents. But if the system is statically unstable, a sufficient condition of stability is obtained. The regions of stability are studied from the sufficient condition so obtained. The Hall currents have a destabilizing character relative to problems where there is a magnetic field without the Hall effect. (auth)

**18495** INDUCTION PHENOMENA IN MHD CONVERTERS WITH CONSTANT AND TRAVELLING MAGNETIC FIELD. Weh, H.; Waltke, G.; Appun, P. (Univ., Brunswich). Energy Convers., 9: 31-8(Mar. 1969).

The subject is considered theoretically under the following headings: Application of theory of complex variables (conformal mapping); application of separation method (conductive converter, inductive converter); application of Fourier methods; and application of finite difference method. (UK)

**18496** ONE-DIMENSIONAL FLOW OF CONDUCTING GAS IN A MAGNETOHYDRODYNAMIC GUN. Kunetsov, N. N.; Starova, E. N. Sb. Rab. Vychisl. Tsen. Mosk. Gos. Univ., 7: 247-63 (1967). (In Russian).

The one-dimensional problem of the runaway of the piston in a semi-infinite tube with an electrically conducting gas in conditions of crossed electric and magnetic fields is considered. The magnetohydrodynamic approximation is used. The dependence of the maximum velocity of the piston on the external magnetic field in the case of an ideally conducting gas is analyzed. It is found that the larger the initial current, the stronger the compression of the gas. In the initial stage of motion, the electromagnetic forces thrusting the gas against the piston create around the piston large compressions with the presence of breakaway of the gas from the closed end of the tube. (Referativnyi Zh.)

**18497** GENERALIZED GREEN'S FORMULAS OF MAGNETO-FLUIDDYNAMICS IN THE CASE OF SLOW MOTION FOR A COMPRESSIBLE FLUID. Ignat, M. Rend. Ist. Lombardo Sci. Lett., A, 100: 965-81(1966). (In Italian).

The fundamental equations of magneto-fluid-dynamics, corresponding to an ionized compressible fluid in an initial magnetic field $H_0 = H_0 k$ (k = unit vector in the direction of z axis), are presented. These equations are the result of a combination of Maxwell's equations and the hydrodynamics equations. The case corresponding to small velocities of the fluid, $\nu$, is considered, so it results that $(\nu \cdot \nabla)\ \nu = 0$. The magnetic field and the density are expressed, respectively: $H = H_0\ (k + h)$ and $\rho = \rho_0\ (1 + \sigma)$, where h = induced magnetic field and $\rho_0$ = initial density. It is also supposed that the fluid moves in a simply connected domain limited by a fixed surface S. Under these conditions are found: a) the generalized Green's formula for the function $\sigma$; b) the generalized Green's formula for the components of the velocity $\nu$; c) the generalized Green's formula for the induced magnetic field h. (App. Mech. Rev.)

**18498** CRITICAL ALFVEN-MACH NUMBERS FOR TRANSVERSE-FIELD MHD SHOCKS. Woods, L. C. (Oxford Univ.). Plasma Phys., 11: 25-34(1969).

Just as ordinary gas dynamic shocks in a gas of zero viscosity, but finite thermal conductivity, do not possess a continuous structure above a certain critical Mach number, MHD shocks in a two-fluid plasma also exhibit discontinuities when viscosity is neglected. These discontinuities occur when the Alfven–Mach number of the shock, $M_A$, exceeds a certain critical value $M_{A*}$; the precise value of $M_{A*}$ depends on which of the three dissipative mechanisms of thermal conductivity for ions and electrons and electrical resistivity are retained and is independent of their actual values. In the practically important case of strong narrow shocks in which ion collisions can be neglected, but the electron gas still exhibits fluid behavior, it is found that $M_{A*} = 3.46$. (auth) (UK)

## Geophysics (Upper Atmosphere)

*Refer also to abstracts 18316 and 18464.*

**18499** (AD-670201) SATELLITE SCINTILLATION AT HIGH LATITUDES AND ITS POSSIBLE RELATION TO PRECIPITATION OF SOFT PARTICLES. Progress Report No. 4, August 1965–April 1966. Frihagen, Jon (Auroral Observatory, Tromso (Norway)). 1968. Contract F61052-67-C-0020. 19p. (AFCRL-68-0285). CFSTI.

Results are presented of a study of the scintillation of the 40-MHz signal from the Polar Orbiting Beacon Satellite BE-B. The signal was recorded at a station on Spitsbergen at 78.06°N and 13.63°E. The results are based on data from August 1965 to April 1966. Spatial and diurnal variations of the phenomenon are established and the results are related to other geophysical parameters. A simple model of production of the irregularities by precipitation of low-energy particles is discussed. (USGRDR)

**18500** (AD-670585) IONOSPHERIC RESEARCH USING SATELLITES. Annual Scientific Report No. 3. Mass, Jonathan; Houminer, Zwi (National Committee for Space Research, Haifa (Israel). Radio Observatory). Feb. 29, 1968. 33p. (AFCRL-68-0314). CFSTI.

Results of measurements of electron content, of ionospheric slab thickness, and of scintillations from three low-latitude stations are presented. The three stations are Nairobi, Kingston, and Haifa. Measurements were made at the three stations of the Faraday polarization rotation of radio signals from the ionospheric beacon satellites S-66 and BE-C, during the period March–June 1965. The results show similar diurnal variations of electron content for the three stations, with a ratio of daytime maximum to predawn minimum of 8 to 10. Large variation in daytime values of

electron content appear between Nairobi and Haifa, indicating large latitudinal gradients. The daytime values at Kingston and Haifa differ by about 25%. There are similar results of slab thickness and of scintillation occurrence at Haifa and Kingston, while at Nairobi the slab thickness values are lower and there is an increase in the percentage of scintillation occurrence, in comparison to the other two stations. Results of electron content for the declining phase of the solar cycle for mid-latitude stations show a marked dependence on the sunspot number. Results of electron content at Haifa for the increasing phase of the sunspot cycle show similar relationship between electron content and sunspot number. (auth) (USGRDR)

**18501** (AD-671061) AN EXPERIMENTAL TEST OF THE ACOUSTIC-GRAVITY WAVE INTERPRETATION OF TRAVELLING IONOSPHERIC DISTURBANCES. Interim Report, April 1, 1967-March 31, 1968. Thome, George D.; Rao, Pendyala B. (Raytheon Co., Burlington, Mass. Spencer Lab.). May 1968. Contract DA-01-021-14482(Z). 51p. CFSTI.

The results of simultaneous hf Doppler and uhf incoherent backscatter measurements of the traveling ionospheric disturbances observed at Arecibo during the summer of 1967 are presented. One of the prime objectives in conducting this series of experiments involving 3 spaced-phase path sounders and the backscatter radar is to examine the gravity-wave interpretation of the large-scale traveling disturbances. The analysis of the observations is based upon three distinct techniques: (1) cross-correlation analysis of the hf Doppler records for an accurate estimate of the wave velocity; (2) hf ray tracing for demonstrating the self-consistency of the hf and the incoherent backscatter data; and (3) the coupling of acoustic gravity waves to the ionospheric plasma. It is concluded from the results of the analysis that the large-scale traveling ionospheric disturbances are truly a manifestation of the acoustic-gravity waves. Finally, some aspects of the analysis which will be refined in the next phase of the study are also outlined. (auth) (USGRDR)

**18502** (AD-672808) LANGMUIR PROBES FOR DETERMINING IONOSPHERIC PARTICLE DENSITIES AND TEMPERATURES. Seljaas, Karl G. (Utah Univ., Salt Lake City. Upper Air Research Lab.). June 1968. Contract F19628-67-C-0275. 107p. (AFCRL-68-0306). CFSTI.

The development of a rocket-borne Langmuir probe system for ionospheric research is described. Particular emphasis is placed on D- and E-region electron temperature and density measurement techniques. Present theory is discussed and found to be unsatisfactory for the rocket probe in the collision dominated D region. The development of the electronic instrumentation is cataloged and the results from a number of rocket flights are analyzed. The probe system that is recommended consists of a function generator that biases the electrode alternately between the electron acceleration region and the positive ion accelerator region and a high input impedance logarithmic amplifier capable of compressing five decades of data in the 0- to 5-volt output range. Currents can be monitored over the ambient temperature range of -10 to +50°C. (auth) (USGRDR)

**18503** (AD-673937) OPTICAL ENERGY TRANSFER PROCESSES. Final Report. Linevsky, M. J. (General Electric Co., Philadelphia, Pa. Missile and Space Div.). July 1968. Contract DAHC04-67-C-0065. 33p. (AROD-7508:4). CFSTI.

Experimental and analytical investigations were carried out on photo-excitation and ionization processes in barium and titanium systems. It is shown that, in order to explain the observed rates of photoionization of barium clouds, photoionization involving barium metastables must be assumed. Population of these metastables can be achieved through an optical pumping process involving resonance absorption from the ground state followed by branching into the metastable levels. A quasi-steady-state analysis of this process indicates that an f number of approximately 0.1 is necessary to explain the observed rates of ion production in the barium clouds. Experimental studies using both optical absorption techniques and photoionization mass spectrometry indicate this f number to be in the range of 0.01 to 0.1. (auth) (USGRDR)

**18504** (AD-673991) PROPAGATION OF Pc1 GEOMAGNETIC MICROPULSATIONS IN THE MAGNETOSPHERE AND THE IONOSPHERE. Final Report. Ellyett, C. D.; Fraser, B. J.; Bagnall, F. T.; Manchester, R. N.; McNabb, P. W. (Newcastle Univ. (Australia). Dept. of Physics). Apr. 1968. 157p. CFSTI.

The report details original equipment for continuously recording Pc 1 geomagnetic micropulsations on magnetic tape with timing accuracy of less than 0.1 second. Analysis of the records is carried out by using both frequency-time and amplitude-time techniques. An extensive study of temporal variations in Pc 1 in relation to propagation in the magnetosphere is detailed. Signals are generated in the lambda = 4.5 to 9.5 region of the magnetosphere and show diurnal and geomagnetic disturbance variations. The theoretical problem of north-south propagation of Pc 1 signals in an ionospheric duct is treated. Comparison with experimental results shows that wave group velocities in the duct vary from 400 to 800 km/sec, depending on the electron concentration in the duct and hence local time. (auth) (USGRDR)

**18505** (AD-673995) THE FLUORESCENCE OF AIR AND NITROGEN EXCITED BY ENERGETIC ELECTRONS. Final Report, March 12, 1964-February 11, 1967. O'Neil, Robert; Davidson, Gilbert (American Science and Engineering, Inc., Cambridge, Mass.). Jan. 1, 1968. Contract AF19(628)-4080. 150p. (ASE-1602; AFCRL-67-0277). CFSTI.

The optical radiation from air and nitrogen bombarded by energetic (keV) electrons was measured over a wide range of gas pressures. Absolute fluorescent efficiencies of spectra from 3,200 to 11,000 A are presented for air and nitrogen at both 22 torr excited by 10-keV electrons and 600 torr excited by 50 keV electrons. At lower pressures, absolute intensity measurements were made in the form of electron excitation cross sections for the first negative and Meinel bands of $N_2^+$. The radiative lifetimes of the Meinel bands are also given. The pressure dependence of the first and second positive systems of N2 and the first negative and Meinel systems of $N_2^+$ was analyzed. With the exception of the Meinel bands, the Stern-Volmer collisional quenching mechanism accurately describes the pressure dependence of these systems in nitrogen and air. Based on the Stern-Volmer analysis, the absolute intensity of the electron induced fluorescence is determined for various transitions of these four band systems for any pressure of air or nitrogen. (auth) (USGRDR)

**18506** (N-68-19396) STUDIES OF IONOSPHERIC ABSORPTION MEASUREMENTS. Its Aeronomy Report No. 22. Shirke, J. S. (Illinois Univ., Urbana. Aeronomy Lab.). Oct. 1, 1967. 132p. (NASA-CR-93694). CFSTI.

Several aspects of ionospheric absorption measurements are presented. The phenomenon of the so-called "winter anomaly" in ionospheric absorption is described, and various ground-based techniques normally available for the detection of the anomaly are discussed. A criterion for the detection of the anomaly is presented and successfully tested by carrying out two series of rocket measurements during normal and anomalous conditions in the winter of 1965 through 1967. A comparison of the results obtained from the rocket experiments with those derived from the ground-based techniques, shows that the winter anomaly is caused due to enhancements in electron number density in the lower ionosphere. (auth) (STAR)

**18507** (N-68-19857) A DIURNAL VARIATION OF THE INTENSITY AND ENERGY SPECTRUM OF LOW-ENERGY ELECTRONS INCIDENT AT FT. CHURCHILL, CANADA. Webber, W. R. (Adelaide Univ. (Australia). Dept. of Physics). Jan. 1968. 35p. (NASA-CR-93740). CFSTI.

Measurements are reported which confirm and extend the observations of a large diurnal intensity variation reported previously. It is concluded that: (1) the effective daytime cutoff near Ft. Churchill is ≈160 MeV; (2) the nighttime cutoff is ≈15 MeV but may fluctuate with time; and (3) the transition from day-to-night conditions occurs within a period of one hour between 1800 and 1900 hours local time. These results are related to recent calculations based on the entrance of particles through the magnetospheric tail and their subsequent motion in the geomagnetic cavity. The re-entrant albedo intensity between 16 to 160 MeV present in the daytime is compared with other observations of these particles at lower latitudes. The extraterrestrial electron intensity present at night between 15 and 160 MeV is obtained and found to be substantially lower than previous observations have indicated. (auth) (STAR)

**18508** THE NIGHT AIRGLOW SPECTRUM AT 1.02 TO 1.13 μ. Harrison, A. W. (Univ. of Calgary, Alberta). Planet. Space Sci. 17: 173-9(Feb. 1969).

The differential brightness of the night airglow spectrum was measured at a spectral resolution of 27 Å between 1.02 and 1.13 μ. Both the (4-1) and (5-2) OH bands were completely resolved into P, Q, and R branches. Rotational temperatures of 240 ± 20°K and 220 ± 20°K respectively were obtained for the bands by comparison with synthetic spectra. Measurement of the branch intensity ratios for the (5-2) band leads to the conclusion that the Q branch is weaker than expected. Absolute brightness values, referred to the zenith, for the (4-1) and (5-2) bands are 6.7 ± 0.5 kR and 7.3 ± 0.6 kR. (auth) (UK)

**18509** A MEASUREMENT OF AURORAL ELECTRONS IN THE 1- TO 10-MeV RANGE. Van Gils, J. N.; Van Beek, H. F.; de Feiter, L. D.; Hendrickx, R. V. (Univ. of Utrecht). Planet. Space Sci., 17: 255-60(Feb. 1969).

Particle fluxes were measured by means of shielded Geiger–Müller telescopes mounted in a rocket, which was launched from ESRANGE(Kiruna) into a diffuse aurora. The analysis of the dependence of the counting rates on altitude indicates that a weak flux of energetic electrons, 1 to 10 MeV, has been detected. (auth) (UK)

**18510** PROPAGATION OF HYDROMAGNETIC WAVES NORMAL TO THE MAGNETIC FIELD IN THE PRESENCE OF CURRENTS. Abbas, M. (Univ. of Rhode Island, Kingston). Planet. Space Sci., 17: 247-54(Feb. 1969).

Hydromagnetic waves propagated normal to the magnetic field in the presence of a steady current density are investigated. Current densities and parameters characteristic for parts of the ionosphere and magnetosphere are considered. The current density is introduced into the macroscopic equations by assuming drift velocities of the electron and ion fluids. Solutions of the dispersion relation which follow from these equations are considered for special cases. Two special cases for propagation normal to the magnetic field are considered. In the first case, propagation normal to the magnetic field with currents along the propagation vector is considered. Solutions of the dispersion relation for this case correspond to stable waves. The second case deals with propagation normal to the magnetic field with currents normal to both the propagation vector and the magnetic field. Solutions of the dispersion relation for this case indicate a convective instability arising from the presence of the transverse currents. The waves may be amplified in this case. Some numerical results for data representative of the ionosphere and magnetosphere are given. (auth) (UK)

**18511** EFFECT OF NEUTRAL SHEET CURRENTS ON THE SHAPE AND MAGNETIC FIELD OF THE MAGNETOSPHERE TAIL. Spreiter, John R.; Alksne, Alberta Y. (Ames Research Center, Moffett Field, Calif.). Planet. Space Sci., 17: 233-46(Feb. 1969).

A modification of the usual first-order theory of the shape of the magnetosphere boundary is described that incorporates in a simple way the principal effects of the electrical currents in the neutral sheet of the extended geomagnetic tail. Numerical results presented for a variety of representative cases show that an additional flaring out of the magnetosphere tail, ultimately of the order of a few Earth radii, occurs over a distance of several tens of Earth radii, and that there is an associated decrease in the intensity of the magnetic field because of the need to approximately conserve the total magnetic flux in each half of the tail cross section. Comparisons with data obtained in space with Explorer 18 and 33 satellites and Pioneer 6 and 7 spacecrafts show that this modification of the theory leads to a substantial improvement in the agreement between the calculated and observed dimensions of the magnetosphere tail and the strength of the magnetic field contained therein. (auth) (UK)

**18512** UPPER ATMOSPHERE DURING GEOMAGNETIC DISTURBANCES. III. SOME REGULARITIES IN DENSITY VARIATIONS. Truttse, Yu. L. (Inst. of Physics of the Atmosphere, Moscow). Planet. Space Sci., 17: 181-7(Feb. 1969).

Upper atmospheric density and the sum of AE indices for the previous 10 hr have a linear relationship, while the relationship between the former and solar radio flux $F_{10.7}$ is nonlinear. The increase in density slows down at great solar activity levels. Some considerations are presented on the nature of the relationship between density and AE and $F_{10.7}$. (auth) (UK)

**18513** UNIVERSAL TIME CONTROL OF THE POLAR IONOSPHERE. Challinor, R. A. (Commonwealth Scientific and Industrial Research Organization, Camden, New South Wales). Nature (London), 221: 941-5(Mar. 8, 1969).

It has been demonstrated that, at very high latitudes, the critical frequency and height of the ionospheric F2 layer are strongly dependent on Universal Time. Studies leading to this conclusion are outlined, including the effects of vertical drifts in ionization caused by atmospheric winds in the F layer. The present author considers it debatable whether these winds are chiefly responsible for the UT control in the polar ionosphere, and examines the evidence. It is concluded that experimental evidence for the vertical drift theory is not convincing, and that such drift cannot alone be responsible for the observed behavior of the polar F region. More than one mechanism is probably responsible, and it may be that the observed phenomena are caused by a combination of vertical drifts due to atmospheric winds and "dumping" of particles by a "geomagnetic tide" (see Duncan, J. Geophys. Res. 67: 1823 (1962)). (UK)

**18514** THE DENSITY OF THE ATMOSPHERE AT ABOUT 600 AND 1050 km ACCORDING TO DATA FROM "ECHO 2" AND "EXPLORER 19". Bozhkov, Rumen; Gogoshev, Mitko. Izv. Sekts. Astron., Bulg. Akad. Nauk, 2: 29-38(1967). (In Bulgarian).

The density of the higher layers of the atmosphere is calculated on the basis of the contraction of the orbital periods of the satellites "Echo 2" and "Explorer 19." A diurnal effect in the change of density, explained with the solar activity, is found and the influence of the solar wind is calculated. (Abstr. of Bulg. Sci. Lit.)

**18515** EXPERIMENTS TO DETERMINE THE STRUCTURE OF THE GEOMAGNETOSPHERE. Hodder, D. T.; Fowler, R. A.; Kert, J. (North American Aviation, Inc., Downey, Calif.). ISA (Instrum. Soc. Amer.), Proc., Nat. Aerosp. Instrum. Symp., 13th, San Diego, 1967, 279-87(1967).

From 13th National Aerospace Instrumentation Symposium, San Diego, Calif. See CONF-670658.

A recommended spaceborne experiment system and analysis techniques applied to geomagnetic perturbation data resulting from high-altitude nuclear weapons detonations are defined. As a result of these analyses, a theoretical model is derived, based upon a magnetohydrodynamic resonance, which explains the uniqueness of prominent electromagnetic effects of high-altitude nuclear detonations in the 0.1- to 1.0-Hz frequency range. The resonance is formed in the region bounded by the two critical points at which the gradient of the Alfvén phase velocity changes sign. This is analogous to a series of strings (geomagnetic field lines) bounded at their extremes by the locus of critical points which form nearly spherical concentric surfaces at 300- and 3,000-km altitudes (Alfvén duct), with its central portion mission between ±35° geomagnetic latitude due to magnetic field lines not intersecting the upper boundary. The transverse (Alfvén) waves are guided along the field lines, encounter partial reflection at the critical surface, maintain resonance for a time, and decay. At the lower boundary, the signal leaking out is converted into other MHD modes propagated downward through the exosphere and ionosphere, and degenerates to electromagnetic signals at the atmosphere interface. This model explains signal simultaneity, duration, frequency content, and harmonic structure. Due to the variation in the length of the field lines and Alfvén speed within the region, resonant frequencies vary according to the latitude at which the disturbance is measured. Signal duration is related to energy dissipation rate. (auth)

**18516** POLAR CHORUS EMISSION AND WORLDWIDE GEOMAGNETIC VARIATION. Hayashi, K.; Kokubun, S.; Oguti, T. (Tokyo Univ.). Rep. Ionosphere Space Res. Jap., 22: 149-60 (1968).

Comparisons are made between vlf chorus emission data observed at Syowa Base, Antarctica, and magnetograms for low latitude stations. It is found that vlf chorus variations are closely related to ssc, si, and also worldwide changes in magnetic field, which are thought to be caused by compressions or expansions of the magnetosphere. It is shown that a sudden impulse in the geomagnetic field is associated in most cases with polar chorus variation in the daytime, and that a positive impulse is accompanied by a sudden enhancement or commencement of chorus. A negative impulse is associated with sudden decrease or fade-out of chorus emission. The center frequency of chorus tends to increase at times of positive magnetic variations, and the rate of this frequency change is closely related to the magnitude of the corresponding magnetic variation. It is suggested that polar chorus originated in electron cyclotron instability in the magnetosphere, $L = 6 \sim 10$. (auth)

**18517** WORLDWIDE GEOMAGNETIC CHANGE PRECEDING THE ONSET OF AURORAL ELECTROJET. Iijima, Takesi; Fukushima, Naoshi; Kamide, Yohsuke (Tokyo Univ.). Rep. Ionosphere Space Res. Jap., 22: 161-72(1968).

About 1 to 1.5 hours before the onset of an individual auroral electrojet, a worldwide increase in the geomagnetic H component of 10 to 15 gammas usually occurs in temperate and low latitudes, which may be designated as AEJ precursor. Characteristics of this pre-bay phenomenon are definitely different from those of SSC's and SI's. AEJ precursors have duration of a few tens of minutes, with time lags of 5 to 15 minutes from midnight to noon regions on the Earth. The magnitude of an AEJ precursor is nearly proportional to $\cos \Phi_m$ ($\Phi_m$ is geomagnetic latitude), without noticeable equatorial enhancement. A geostationary ATS-1 satellite detects a simultaneous H increase in the magnetosphere. At the satellite, a greater amplitude (a few times) is observed a few minutes earlier than on the ground, and an increase in low-energy plasma density is also observed. During the pre-bay phenomenon, $S_q^p$ current in the polar region is enhanced, especially on the day side. These observations suggest an inward surging of plasma flow from the magnetospheric tail before the onset of an isolated AEJ. (auth)

**18518** THREE-DIMENSIONAL ELECTRIC CURRENT AND TOROIDAL MAGNETIC FIELD IN THE IONOSPHERE. Fukushima,

Naoshi (Tokyo Univ.). Rep. Ionosphere Space Res. Jap., 22: 173-95(1968).

The height dependence of the Pedersen and Hall conductivities in the ionosphere results in a vertical current circulation within the ionosphere, even when the electromotive force is everywhere horizontal and height-independent. The vertical current circulation produces a toroidal magnetic field observable only in the ionosphere and not on the ground. The presence of an intense toroidal magnetic field accompanying the equatorial electrojet was suggested by Untiedt (1967). The magnitude of the toroidal magnetic field accompanying the Sq field is shown to be greater than half the geomagnetic Sq variation field observed on the ground. The toroidal magnetic field in the ionosphere is antiparallel to the Sq current in the northern hemisphere and parallel in the southern hemisphere. A local enhancement of ionospheric conductivity produces a toroidal magnetic field in the ionosphere if the enhancement is sharply height-dependent, the resultant toroidal field being of the same order of magnitude as that observed on the ground due to the height-integrated electric current in the ionosphere. Auroral electrojets are accompanied by east–west toroidal magnetic fields in and above the ionosphere, if an external electric field is supplied from the magnetosphere. The toroidal fields associated with westward auroral electrojets may be of a few hundred gammas in magnitude, and the direction depends on whether the external electric field is westward or equatorward. The detection of a toroidal magnetic field in the ionosphere or its leakage to the ground will provide clues to the production mechanism of electric current in the ionosphere and magnetosphere. (auth)

**18519** POSITIVE AND NEGATIVE CORRELATIONS OF GEOMAGNETIC FLUCTUATIONS AT CONJUGATE-PAIR STATIONS SYOWA BASE AND REYKJAVIK. Oguti, Takasi (Tokyo Univ.). Rep. Ionosphere Space Res. Jap., 22: 197-200(1968).

The conjugate relationship between the magnetic variation at Syowa Station and that at Reykjavik was examined. Whether or not a good or poor correlation is found at the conjugate pair is due only to the small displacement of real conjugate points. Two days were selected, Sept. 3–4 and Sept. 19–20, 1959. The value of the horizontal component was read out every 2.5 minutes. (W.D.M.)

**18520** A MODIFIED PLASMA RESONANCE OBSERVED BY A ROCKET-BORNE GYRO-PLASMA PROBE. Ejiri, Masaki (Tokyo Univ.); Oya, Hiroshi; Obayashi, Tatsuzo. Rep. Ionosphere Space Res. Jap., 22: 201-4(1968).

Using Bolmain's formula (1964) for a short cylindrical probe immersed in a homogeneous magnetoactive plasma, Oya (1968) predicted a new kind of plasma resonance, viz., a modified plasma resonance, near the upper hybrid resonance. The experimental evidence for both the upper hybrid and modified plasma resonances is discussed, using data obtained from a Lambda 3H-2 sounding rocket. (W.D.M.)

**18521** TRANSIENT IONOSPHERIC PHENOMENA IN ANTARCTICA. Davies, K.; Jones, J. E. (Environmental Science Services Administration, Antarctica). Antarct. J. U. S., 3: 197-8(Sept.-Oct. 1968).

The frequency stability of high-frequency (hf) waves reflected from the Antarctic ionosphere was studied and this stability compared with that of ionospheric echoes over similar propagation distances in middle latitudes. Also, the horizontal motions of large-scale traveling ionospheric disturbances (TIDs) in the polar and auroral regions were studied. Evidence from vertical soundings indicates that the ionosphere in high latitudes is much more disturbed than in middle latitudes. Thus, greater frequency spreading of ionospheric echoes may be expected in Antarctica than in the United States. Such data are of importance in the design of hf communication systems as well as for their diagnostic value in studying the ionosphere. Some of the TIDs seen in middle latitudes during magnetic disturbances are believed to originate in or near the auroral zones. If this is so, observations in Antarctica may help to locate and identify the sources of these TIDs. Methods used are described. At the time that physical contact with the Antarctic stations ceased for the winter in February, the 6-MHz signal was just beginning to break through the E layer, so few data are available. Shown are a sample record from Antarctica and, for comparison, a record for a middle-latitude path of about the same length for the corresponding season and local time. In general appearance, the 2 parts of the figure are similar, with the spread of the spectrum of the Antarctic signal being somewhat greater than that of the middle-latitude signal. This difference reflects the tendency of the ionosphere to be more disturbed in high latitudes than in low latitudes. (BBB)

**18522** ENERGETIC-PARTICLE PRECIPITATION OVER ANTARCTICA. Reid, G. C.; Hargreaves, J. K.; Ecklund, W. L.; Leinbach, H.; Sauer, H. H. (Environmental Science Services Administration, Antarctica). Antarct. J. U. S., 3: 199-200(Sept.-Oct. 1968).

Some recent results of analysis of the data obtained from riometers operated in Antarctica are described. During 1966–1967, essentially continuous data were obtained from 30-MHz riometers with vertically directed antennas at Byrd, South Pole, and Vostok Stations, and from an array of four 30-MHz riometers with antennas aimed obliquely in the north, south, east, and west directions at Byrd. Analysis of the polar cap absorption events was made and comparison with satellite measurements of proton spectra revealed significant diurnal differences in the correlation between riometer absorption and proton flux. This finding has an important bearing on understanding of photochemical effects in the lower ionosphere. The principal objective of the multiple-antenna installation at Byrd was to study the conjugate behavior of auroral-absorption events in conjunction with a similar riometer system of Great Whale River, Canada, which is close to the computed magnetic conjugate point of Byrd. Plots of absorption vs time for the 5 channels recorded at Byrd on December 28, 1966, are shown. The center of the absorption region underwent a diurnal change in latitude on this day. Many of the same peaks could be identified in the records made simultaneously at Great Whale River. For the months of November and December (northern winter and southern summer), it was found that, on the average, Byrd and Great Whale River are conjugate during the daytime sector (centered on 1700 UT), and the events at Great Whale River are larger (the average interhemispheric absorption ratio at noon is 2:1). In this case, the difference in event magnitude must be due to a true hemispheric difference in the intensity of the absorption events rather than to a displacement of conjugate points. At other times of day and in other seasons there may be considerable displacement of the conjugate points. (BBB)

**18523** VLF STUDIES IN ANTARCTICA. Crary, J. H. (Environmental Science Services Administration, Antarctica). Antarct. J. U. S., 3: 202-3(Sept.-Oct. 1968).

Continuous recordings are made at Byrd and Plateau Stations of the relative phase and amplitude of signals from vlf transmitters GBR (16.0 kHz), Rugby, U. K.; NAA (17.8 kHz), Cutler, Maine; NSS (21.4 kHz), Annapolis, Maryland; NPM (23.4 kHz), Oahu, Hawaii; and NWC (15.5, 18.0, 19.8, and 22.3 kHz), North West Cape, Australia. Last year's vlf records from Byrd and Plateau Stations were surveyed. Information about polar cap events that occurred during this period are of considerable interest, since both temporal and spatial variations are becoming evident in vlf measurements made in the northern hemisphere. The measurements in both hemispheres will supplement each other and increase the value of the data considerably. Both Byrd and Plateau Stations have digital data-acquisition systems which provide data at more frequent intervals than was practical by hand scaling. (BBB)

**18524** CONJUGATE POINT STUDIES. Spitz, A. Lawrence (Arctic Inst. of North America, [Antarctica]). Antarct. J. U. S., 3: 207(Sept.-Oct. 1968).

Scanning of the visible aurora was done to determine how the solar wind (plasma ejected from the Sun) affects the Earth's field. Since 1965, photoelectric photometers and all-sky cameras using black-and-white and color film have been recording auroral activity at Great Whale River on the eastern shore of the Hudson Bay and at Byrd Station in Antarctica (geomagnetic conjugates in the Northern and Southern Hemispheres). The observations taken at these conjugate points were synchronized by highly accurate clocks and matched according to auroral displays occurring simultaneously, or nearly so, in both hemispheres. Observations of fluctuations in the geomagnetic field in both hemispheres suggest that, considering Byrd Station as a fixed point, the northern conjugate was wandering. In July 1967, observations were taken by a photometer on an island in Hudson Bay 80 miles from Great Whale River to supply confirming evidence of this conjugate wandering. (BBB)

**18525** GEOMAGNETIC PULSATIONS DURING A MAGNETIC STORM IN THE SOUTHERN AURORAL ZONE. Inoue, Yuji; Tartaglia, Nunzio A. (Univ. of Pittsburgh). Antarct. J. U. S., 3: 201-2(Sept.-Oct. 1968).

Geomagnetic pulsations observed at Byrd Station (geomagnetic lat. 70.6°S., long. 336.3°; geographic lat. 80.0°S., long. 119.5°W; L ~ 7.25) during a moderately disturbed condition were studied. The analyzed period was from 1000 UT on April 1 to 1000 UT on April 2, 1964. Central reverses of negative bays were caused by geomagnetic pulsations which start at or before the onset of bays and increase in amplitude with the bay development. Usually, this

inward motion of plasmas preceded the initial decrease of a negative bay. From the oscillatory fluctuations, the power spectra of geomagnetic pulsations were computed by the fast Fourier transformation. Assuming an overhead current in the E region and a reasonable magnitude of the electrical conductivity ($\sigma \sim 2 \times 10^{-14}$ emu), it was possible to estimate the wave electric fields, phase velocities, and wavelengths for the activity centers seen in the dynamic spectra. For instance, for the pulsation that occurred around 1600 UT on April 1, whose period was 16 min, $E \simeq 2$-mV/m, $\Delta B \simeq 30\gamma$, $\omega/k \simeq 100$ Km/sec, and $\lambda \simeq 20$ $R_E$ (the length of the magnetic line of force passing through Byrd Station) were obtained. Also, for different isolated peaks in the dynamic spectra, similar phase velocities were obtained. Therefore, the oscillatory variations seem to be waves appearing in the entire magnetic tube passing through Byrd Station. General similarity can be seen in the power spectra of different magnetic components. (BBB)

**18526** ANTARCTIC GEOPHYSICAL RESEARCH AND DATA ANALYSIS. Coroniti, Samuel C.; Penndorf, Rudolf B. (Avco Corp., Lowell, Mass.). Antarct. J. U. S., 3: 204-7(Sept.-Oct. 1968).

A general survey of the Antarctic ionosphere and the electron-density variation in the upper F layer during magnetic storms are presented. In the E region, the production of ions by nonsolar precipitating electrons and protons (in the keV range) is an important source of ionization in the auroral zone during the dark hours. This enhancement of the E region was determined from data obtained at several Antarctic stations. Its occurrence between 0600 and 1200 local magnetic time shows that it is related to drizzle-type electron precipitation. Synoptic maps of $f_0F2$ were prepared for an 18-month period. The path of the mean trough of $f_0F2$ follows more or less the geographic latitude 60°S. The trough forms over the Indian Ocean at 1500 UT and follows a regular path until it reaches the area north of the Ross Sea at 1500 UT, when it splits in two, with one trough on either side of dip pole longitude 144°E. During the summer, the main trough moves around the dip pole, indicating a predominant influence of electromagnetic drifts at the F2 peak; in winter, on the other hand, the pre-dawn trough is controlled by the Sun and moves along geographic latitudinal circles, with a minor disturbance occurring at the time it reaches the dip pole meridian. Investigations concerning the topside ionosphere based on 3 magnetic disturbances for which Alouette satellite data are available are also discussed. (BBB)

**18527** RADIATION FROM ATOMIC HYDROGEN IN AURORAE. Rees, M. H. (Univ. of Colorado, Boulder). Antarct. J. U. S., 3: 208(Sept.-Oct. 1968).

Study of the hydrogen emissions Balmer $\alpha$ and $\beta$, which was begun during the 1966 austral winter, has been continued at Byrd Station, Antarctica, which is in a region of maximum auroral occurrence. During several 24-hr periods in midwinter, spectra were recorded constantly. Several hundred useful spectra were obtained during the observing season, and photometric records were obtained for calibration and high-time resolution studies. Twilight effects could be seen by the enhancement of the continuum in the blue region of the spectrum and the appearance of sodium emission on the northern horizon. Excellent records were obtained during the big geomagnetic storm of May 25, 1967. The spectra show a large enhancement of the atomic-oxygen red lines over their usual intensity in aurorae. (BBB)

**18528** PROPERTIES OF SPECTRA OF GEOMAGNETIC π2 PULSATIONS RECORDED AT THE BUDKOV ORSERVATORY. Strestik, Jaroslav (Geophysical Inst., Prague). Stud. Geophys. Geod., 13: 42-59(1969).

A more detailed study of the internal structure of Pi2 pulsations was performed using spectral analysis. Selected pulsations, recorded during 1962–1964, are considered. Several morphological regularities are mentioned, followed by the description of the method of obtaining the spectra and of the properties of the spectral characteristics. It is shown that Pi2 pulsations can be resolved into a superposition of three oscillations of different frequencies. In the discussion the results are given in connection with some of the existing theories, from which the possibility of interpretation for all three oscillations, forming the Pi2's, follows. (W.D.M.)

**18529** EFFECT OF THE LOWER IONOSPHERE ON ELECTROMAGNETIC DISTURBANCES WITH PERIODS CORRESPONDING TO MICROPULSATIONS. Bochnicek, Josef (Geophysical Inst., Prague). Stud. Geophys. Geod., 13: 60-75(1969).

This paper solves the transition of a low-frequency electromagnetic disturbance through two mutually different models of the lower daytime ionosphere, the parameters characterizing the lower daytime ionosphere being taken into account. It is possible to show that the structure of the lower daytime ionosphere has an effect on the amplitudes as well as the polarization of observed micropulsations, which is not negligible. (W.D.M.)

# Low-Temperature Physics

*Refer also to abstracts 18475 and 18588.*

**18530** (CEA-Bib-132) PROPERTIES OF LIQUID $^3$He AND SOLUTIONS OF $^3$He IN $^4$He. Breton, Jean-Paul (Commissariat a l'Energie Atomique, Saclay (France). Centre d'Etudes Nucleaires). Oct. 1968. 22p. (In French). Dep. Thesis.

Since the first liquefaction of helium 3, a great deal of theoretical and experimental works has been done to study its properties. First, some of these properties are derived, with the help of very simple theoretical considerations. Next, the experimental works on the properties of pure He-3 are reviewed (equilibrium P–T diagram, density, specific heat, magnetic susceptibility, viscosity, thermal conductivity, zero sound). Finally, the problem of superfluidity and of solutions of He-3 in He-4 are dealt with (isotopic phase separation, λ transition for the mixture). 36 references. (auth)

**18531** RECENT DISCOVERIES IN SUPERCONDUCTIVITY. Matthias, Bernd T. (Inst. of Pure and Applied Physical Sciences, La Jolla, Calif.). Int. J. Quant. Chem., Symp. No. 2, 359-61(1968).

From Symposium on Atomic, Molecular, and Solid-State Theory and Quantum Biology, Sanibel Island, Florida. See CONF-680116.

Three recent discoveries in superconductivity are discussed briefly. These are the isotope effect in α-uranium, superconducting hexa- and dodecaborides, and superconductivity above 20°K. (W.D.M.)

**18532** THE EFFECT OF PHONON INTERACTIONS ON THE ORIENTATIONAL STATE OF $H_2$. Harris, A. Brooks (Univ. of Pennsylvania, Philadelphia). Int. J. Quant. Chem., Symp. No. 2, 347-57(1968).

From Symposium on Atomic, Molecular, and Solid-State Theory and Quantum Biology, Sanibel Island, Florida. See CONF-680116.

Discrepancies between the theoretical and experimental values of: (a) the frequency splitting of the Pake doublet, (b) the values of the quadrupole coupling constant, and (c) the orientational transition temperature for solid $H_2$ are pointed out. It is shown that these discrepancies are significant and can be at least partially explained by consideration of the interactions between molecular rotations and lattice vibrations. A table of revised experimental values of the quadrupole coupling constant, Γ, is given. (auth)

**18533** ON THE NATURE OF THE CRITICAL CURRENTS IN A SURFACE SUPERCONDUCTING LAYER. Akhmedov, S. Sh.; Karasik, V. R.; Rusinov, A. I. (Lebedev Inst. of Physics, Moscow). Zh. Eksp. Teor. Fiz., 56: 444-53(Feb. 1969). (In Russian).

An induction method is employed for measuring the critical currents of surface superconductivity in fields $H_{c2} < H < H_{c3}$ for niobium samples of various degree of purity. For a very pure sample (resistance ratio 14,000) the critical current was negligible (< 0.002 A/cm). The explanation offered for this fact is that under the influence of an arbitrarily small normal magnetic field component the near-surface layer goes over to a vortex state. Data on the angular dependence of the critical current and of field $H_{c3}$ and also the results of temperature measurements are presented. (auth)

**18534** ON "$T_C$ ANISOTROPY" IN THE SUPERCONDUCTING TRANSITION. Shepelev, A. G.; Filimonov, G. D. (Physical-Technical Inst. of Low Temperatures, Kharkov). Zh. Eksp. Teor. Fiz., 56: 472-7(Feb. 1969). (In Russian).

Results of a precise investigation of absorption of ultrasound in pure tin single crystal of various orientation are presented. The measurements are performed by the pulse method at temperatures between 4.2 and 1.3°K and frequencies between 130 and 215 Mc under various experimental conditions. It is found that with an accuracy of ±0.0002°K the beginning of decrease of the electron ultrasound absorption coefficient (for $\hbar\omega \ll 2\Delta$) is independent of crystallographic orientation during transition of the metal from the normal to superconducting state. (auth)

**18535** INVESTIGATION OF THE FERMI SURFACE IN MOLYBDENUM ON BASIS OF THE RADIO FREQUENCY SIZE EFFECT. Boiko, V. V.; Gasparov, V. A.; Gverdtsiteli, I. G. Zh. Eksp. Teor. Fiz., 56: 489-500(Feb. 1969). (In Russian).

The radio frequency size effect in thin plane-parallel molybdenum plates is studied at a frequency of 3 to 20 Mc and temperatures between 1.7 and 4.2°K. Anisotropy of the extremal dimensions of the Fermi surface is investigated in three crystallographic planes (110), (111), and (121). The results obtained permit one to determine the shape and dimensions of the electron and hole surfaces. The cross sections observed were identified by taking into account the dependence of the size effect lines on the inclination of the magnetic field with respect to the sample surface and polarization of the high frequency field. The complex shape of the isoenergetic electron surface results in the appearance of a number of size effect lines due to the presence of breaks in the electron trajectories in the magnetic field. No lines have been observed which speak in favor of the Fermi surface being an open surface; this confirms the existence of a gap between the hole octahedron and the electron "jack." The mean current carrier velocities in the central part of the electron and hole surfaces can be determined from the results and are respectively $\bar{v}_e = 0.60 \times 10^8$ cm/sec, $\bar{v}_h = 0.89 \times 10^8$ cm/sec. (auth)

**18536** CRITICAL CURRENTS IN A SUPERCONDUCTING ALLOY WITH A RIGID VORTEX LATTICE. Bychkov, Yu. F.; Vereshchagin, V. G.; Karasik, V. R.; Kurganov, G. B.; Mal'tsev, V. A. (Lebedev Inst. of Physics, Moscow). Zh. Eksp. Teor. Fiz., 56: 505-15(Feb. 1969). (In Russian).

A model of a superconductor of the second kind with a vortex lattice rigidly fixed on inhomogeneities is proposed in which destruction of superconductivity by a current in an external magnetic field is due to the superconducting condensate attaining the critical velocity. The model is verified for a Ti–22 at.% Nb alloy in which highly dispersed transition and equilibrium phase precipitates uniformly distributed throughout the volume can be obtained. Satisfactory agreement between theory and experiment is obtained. A close relation between the structural state of the alloy and its superconducting properties is established and explained. An explanation is offered for the so-called "peak effect" on the $j_c(H)$ curve. (auth)

**18537** SUPERCONDUCTIVITY IN LAMELLAR SEMICONDUCTING STRUCTURES. Pashitskii, E. A. (Inst. of Physics, Kiev). Zh. Eksp. Teor. Fiz., 56: 662-9(Feb. 1969). (In Russian).

It is shown that longitudinal collective oscillations of free carriers (of the "surface wave" type) exist on the interface between strongly alloyed semiconductors of the n and p types with equal work functions (heterotransition) but with very different conductivity electron and hole masses ($m_n \ll m_p$), the mobility of the holes being sufficiently high. The problem of interaction between conductivity electrons in a film and surface oscillations of "heavy" holes in p semiconductors is considered for lamellar structures (of the "sandwich" type) consisting of p semiconductors divided by thin layers of degenerate n semiconductors (semimetals). It is demonstrated that under certain conditions the interaction may, in principle, lead to the formation of strongly coupled electron (Cooper) pairs and hence to the appearance in such systems of superconductivity with sufficiently high critical temperatures ($T_c \sim 10^2$ to $10^3$ °K). (auth)

**18538** SUPERCONDUCTING ELECTRIC CABLE. (to Compagnie Generale d'Electricite). British Patent 1,144,170. Mar. 5, 1969. Priority date Aug. 3, 1965, France.

An electric cable is described which comprises a central conductor at least partially of a superconducting metal and a sheath covering the central conductor. The metal of the sheath has at normal temperature an electric conductivity greater than $2 \times 10^7$ mho/m. It has a ratio greater than 50 of conductivity at a temperature at which the central conductor is in a superconductive state, to the conductivity at 300°K. The sheath is formed around the central conductor in such a manner that the inner surface of the sheath is in non-continuous contact with the central conductor, when the cable is viewed in longitudinal section. (M.H.R.)

**18539** COUPLING BETWEEN FERROMAGNETIC LAYERS THROUGH A SUPERCONDUCTOR. Deutscher, G.; Meunier, F. (Faculte des Sciences, Orsay, France). Phys. Rev. Lett., 22: 395-6(Mar. 3, 1969).

Three-layer systems [ferro/super/ferro (FSF)] with very thin insulating junctions between S and both F layers have been prepared. The superconducting transition temperature $T_{c\uparrow\uparrow}$ (when both F magnetizations are parallel) is lower than $T_{c\uparrow\downarrow}$. (auth)

**18540** UPPER CRITICAL FIELD $H_{c2}$ OF SUPERCONDUCTORS FOR ALL ELECTRON MEAN FREE PATHS. Usadel, Klaus-Dieter; Schmidt, Michael (Univ., Goettingen, Ger.). Z. Phys., 221: 35-46(1969).

The ratio $H_{c2}/H_{c2}$ is calculated for all electron mean free paths. Correction terms to the standard result $H_{c2}/H_{c2} = 1695$ are obtained both in the Ginzburg-Landau region and in the dirty limit at all temperatures. In the clean limit our results are identical with those obtained earlier by Lüders. (auth)

**18541** SUPERCONDUCTIVITY. THIRD EDITION. Lynton, E. A. London, Methuen, 1969. 219p. 30s.

The subject is treated under the following main headings: Introduction; basic characteristics; phenomenological thermodynamic treatment; static field description; Pippard nonlocal theory; Ginzburg–Landau phenomenonological theory; surface energy; type II superconductors; isotope effect; thermal conductivity; the energy gap; microscopic theory of superconductivity; superconducting alloys and compounds; superconducting devices. (UK)

**18542** SUPERFLUIDITY WITHOUT SUPERFLOW IN UNSATURATED HELIUM FILMS. Goodstein, David L.; Elgin, Robert L. (California Inst. of Tech., Pasadena). Phys. Rev. Lett., 22: 383-5(Mar. 3, 1969).

It is shown experimentally that the superfluid fraction $\rho_s/\rho$ is continuous and finite at the point at which superflow vanishes in unsaturated helium films. It follows that there is a region of superfluidity without superflow. In addition it is shown that the behavior of the partial molar entropy may account for the disappearance of superflow without requiring that $\rho_s/\rho$ vanish. (auth)

**18543** QUANTUM EFFECTS IN A SINGLY-CONNECTED SUPERCONDUCTING CYLINDER. Shablo, A. A.; Dmitrenko, I. M. (Physico-Technical Inst. of Low Temperatures, Kiev). JETP Lett. (USSR) (Engl. Transl.), 8: 278-9(Nov. 5, 1968).

Translated from Zh. Eksp. Teor. Fiz., Pis'ma Redaktsiyu, 8: 453-4(Nov. 5, 1968).

The resistance of a wire of indium alloyed with 5 at.% lead, with diameters from 1 to 5 $\mu$, was measured as a function of the magnetic field parallel to the wire axis at temperatures near critical. The existence of an oscillatory dependence of the critical temperature of solid small-diameter cylinders is indicated. The preliminary results presented give grounds for assuming quantization by means of surface-superconductivity currents. (M.H.R.)

**18544** INFLUENCE OF THE PURITY OF SUPERCONDUCTING NIOBIUM ON THE SHAPE OF THE MAGNETIZATION CURVE. Karasik, V. R.; Nisel'son, L. A.; Petrusevich, I. V.; Shal'nikov, A. I.; Shebalin, I. Yu. (Lebedeve Inst. of Physics, Moscow). JETP Lett. (USSR) (Engl. Transl.), 8: 294-5(Nov. 5, 1968).

Translated from Zh. Eksp. Teor. Fiz., Pis'ma Redaktsiyu, 8: 479-81(Nov. 5, 1968).

The magnetic properties of pure niobium in the superconducting state were investigated. Magnetization curves were plotted by a ballistic method in a longitudinal magnetic field at 4.2°K. The sample length-to-diameter ratio was 75. The magnetization curve of the initial not-outgassed wire shows that the presence of gas impurities and case hardening greatly distort the shape of the curve. The magnetization curve obtained for samples of the same wire outgassed in a vacuum of $5 \times 10^{-11}$ Torr indicates that at the degree of purification attained, the niobium retained fully its properties of a superconductor of the second kind. In the purest of the samples the resistance ratio reached 14,000. (M.H.R.)

**18545** SUPERCONDUCTING MATERIALS. Merriam, Marshal F. (Indian Inst. of Tech., Kanpur). Proc. Nucl. Phys. Solid State Phys. Symp., 1968, Madras, 104-18(1968).

From Nuclear Physics and Solid State Physics Symposium, Madras, India. See CONF-680212.

The present status of superconductive materials is briefly reviewed under the following broad topics: Introduction — Materials vs Phenomenon; Superconductive Elements, Alloys and Compounds (emphasis on superconducting semiconductors); Technological Aspects; Today's Best Superconductors; and Superconductors of the Future. The author points out that if the early Dutch workers had cold worked their wire and perhaps shifted the stoichiometry a little, results would have been spectacularly better; the development of superconducting materials and magnets would probably have begun in earnest in the 1920's, instead of lying dormant until the 1960's. He feels that perhaps now we are equally close to advancement of equal or even greater magnitude. 32 references. (L.M.T.)

**18546** TECHNOLOGY OF LIQUID HELIUM. Kropschot, R. H.; Birmingham, B. W.; Mann, D. B. (eds.). Washington, D. C., National Bureau of Standards, 1968. 380p. (NBS-MON-111). GPO $2.00.

The discovery of the element helium was made just 100 years ago in 1868. Today helium is produced in large quantities and used in many technological applications. Information on helium resources, production, conversion, thermodynamic properties, liquefaction and refrigeration techniques, transportation and storage of liquid, and safety requirements is presented. Uses for liquid and cold gas in cryoelectronics, superconductivity,

bubble chambers, cryopumping, and missile and space systems are discussed. Articles by noted authorities in cryogenic technology are presented, in which they discuss their specialized field in great depth. (auth)

**18547** EFFECTS OF A MAGNETIC FIELD ON THE OSMOTIC PRESSURE OF DILUTE SOLUTIONS OF $^3$He IN $^4$He AT LOW TEMPERATURES. Ghozlan, Aline; Seiden, Joseph (Faculte des Sciences, Orsay, France). Compt. Rend., Ser. A, B, 267: 1383-6(Dec. 23, 1968). (In French).

The effects of a magnetic field on the osmotic pressure of dilute solutions of He-3 at temperatures $T \ll T_F$ (where $T_F$ is the Fermi temperature of He-3) are studied. The chemical potential is obtained as a function of the magnetic field. (J.F.P.)

**18548** EFFECTS OF DISLOCATION DISTRIBUTION ON THE SPECIFIC HEAT OF DEFORMED TYPE-II SUPERCONDUCTORS. Barbee, T. W. Jr. (Stanford Research Inst., Menlo Park, Calif.). Phys. Status Solidi, 31: 535-44(Feb. 1, 1969).

The effects of dislocation distribution on the mixed-state specific heat of deformed type-II superconductors are considered. Calculations based on a simple model are shown to predict behavior in agreement with reported experimental results for deformed niobium if an internal variation for $\varkappa$ of 0.4 caused by dislocation distribution is assumed. The implications of this result for fluxoid pinning in deformed type-II superconductors are discussed. Applications of measurements of the mixed-state specific heat of type-II superconductors to the study of imperfections and imperfection distribution are also discussed. (auth)

**18549** SUPERCONDUCTING MAGNETS. Luiten, A. L. (Philips Research Labs., Eindhoven, Netherlands). Philips Tech. Rev., 29: 309-22(1968).

The history of the use of superconductors in magnets is sketched briefly. The properties of the various types of superconducting materials and the electrical and magnetic characteristics and the stability of superconducting magnets are discussed. Some experimental superconducting magnets are described. (M.H.R.)

**18550** GINZBURG–LANDAU EQUATIONS AND PHENOMENOLOGICAL TRANSPORT EQUATIONS IN SUPERCONDUCTORS. Rothen, F. (Philipps-Univ., Marburg, Ger.). Helv. Phys. Acta, 42: 210-24(Apr. 1, 1969). (In French).

It will be shown that, in the neighborhood of the critical temperature, the application of the theory of irreversible processes to superconductors necessitates no other specific hypothesis but that of the validity of the time-dependent Ginzburg–Landau equations. Especially, the vanishing of the thermoelectric effects and the particularly simple form of the thermal conductivity in superconductors are connected with the fact that the pseudo wave function $\psi$ introduced by Ginzburg–Landau satisfies a diffusion equation in the mentioned temperature region. (auth)

**18551** THERMAL CONDUCTIVITY IN A PURE TYPE II SUPERCONDUCTOR NEAR THE UPPER CRITICAL FIELD. Noto, Hoshichi (Tohoku Univ., Sendai). J. Phys. Soc. Jap., 26: 710-16(Mar. 1969).

The thermal conductivity, K, of a pure Nb sample (RRR = 1900) was studied as a function of the longitudinal and transverse magnetic fields between 1.8°K and the transition temperature (9.2°K). The thermal conductivity shows a deep minimum just above $H_{c1}$ and increases with infinite slope in the gapless region near $H_{c2}$ like $\Delta K/K_n = C(H_{c2} - H)^{1/2}$, in good agreement with the Maki theory for both longitudinal and transverse field configurations. The temperature dependence of the coefficient C is compared with the numerically calculated one from the revised Maki theory, which includes both the impurity scattering and the phonon scattering, and fairly good agreement is found between them, when the density of states is assumed to be $1.6 \times 10^{33}$ states/cm$^3$ erg. (auth)

**18552** NUCLEAR SPIN–LATTICE RELAXATION IN SUPERCONDUCTING MIXED STATE. Masuda, Yoshika; Okubo, Noriaki (Nagoya Univ., Japan). J. Phys. Soc. Jap., 26: 309-14(Feb. 1969).

The nuclear spin–lattice relaxation time $T_1$ of $^{51}$V in a type II superconductor $V_3Sn$ in the mixed state has been measured. In the case of $T_c(0) > T_c(H) > 0.6\ T_c(0)$, abrupt decrease of $T_1$ appears at the critical temperature corresponding to the magnetic field in which $T_1$ was measured, $T_c(H)$, and then increases gradually. In this case of low magnetic field the high temperatures near $T_c(0)$, the temperature variation of $T_1$ shows the behavior predicted by a Bardeen–Cooper–Schrieffer (BCS) theory of superconductivity. In the case of $T_c(H) < 0.6\ T_c(0)$, just below $T_c(H)$ corresponding to that field, $T_1$ shows no minimum but increases monotonically. These behaviors in the case of high magnetic field and low temperatures can be understood quantitatively on the basis of the theory of gapless superconductivity. (auth)

**18553** FLUX JUMPS IN NONIDEAL TYPE-II SUPERCONDUCTORS. I. THEORY OF FLUX JUMPS IN SLABS. Yamafuji, Kaoru; Takeo, Masakatsu; Chikaba, Jitsuo; Yano, Norio; Irie, Fujio (Kyushu Univ., Fukuoka). J. Phys. Soc. Jap., 26: 315-30(Feb. 1969).

A theory of flux jumps in a slab of a nonideal type-II superconductor is developed by the use of a phenomenological theory of flux motion. To include explicitly in the theory the various quantities which are controllable experimentally, the temperature inside the slab is assumed to be approximately uniform. Then a flux jump is characterized by a catastrophically sharp rise of the temperature of the sample. The criteria for the occurrence of flux jumps are derived under such an assumption, together with the relation between the value of external magnetic field, at which a flux jump starts, and the sweeping rate of the external magnetic field. Various behaviors of flux jumps observed experimentally are reasonably explained by the present theory in a quantitative way. (auth)

**18554** SUPERCONDUCTIVITY OF NIOBIUM FILMS. Asada, Yuji; Nose, Hiroshi (National Research Inst. for Metals, Tokyo). J. Phys. Soc. Jap., 26: 347-54(Feb. 1969).

Niobium films are prepared by evaporation in ultra-high vacuum system with an electron beam and their superconducting properties are examined as a function of film thickness and temperature. An inflection point appearing in the temperature dependence of the parallel critical field $H_{c\parallel}$ is explained by the temperature dependence of the coherence length $\xi(t)$. The perpendicular critical field $H_{c\perp}$ varies as $1-t$ independently of their thickness. The coherence length $\xi(0)$ at 0°K of some films are estimated by three methods. Anomalous results that the minimum occurs on the angular dependence of the critical field and the ratio $H_{c\parallel}/H_{c\perp}$ becomes lower than 1.69 are discussed by considering the isolated columnar structure. (auth)

**18555** A POSSIBLE MECHANISM FOR THE PEAK EFFECT IN TYPE-II SUPERCONDUCTORS. Pippard, A. B. (Cavendish Lab., Cambridge, Eng.). Phil. Mag., 19: 158; 217-21(Feb. 1969).

As $H_{c2}$ is approached the rigidity of the flux-line lattice falls to zero more rapidly than the pinning strength of inhomogeneities. This allows the flux lattice to conform more readily to the configuration that locks it to the inhomogeneous structure, so that the maximum resistanceless current is increased. An idealized model gives an estimate of the height of the current peak in order-of-magnitude agreement with observations. (auth) (UK)

**18556** WORLD'S LARGEST SUPERCONDUCTING MAGNET FOR MHD. Cryog. Eng. News, 4: No. 3, 38; 47(Mar. 1969).

A schematic of the MHD power generating system including the superconducting magnet is shown. Certain operating data for the MHD generator and the superconducting magnet are given. (M.H.R.)

**18557** SUPERCONDUCTING OXIDES OF RHENIUM AND MOLYBDENUM WITH TUNGSTEN-BRONZE-TYPE STRUCTURES. Sleight, A. W.; Bither, T. A.; Bierstedt, P. E. (E. I. du Pont de Nemours and Co., Wilmington, Del.). Solid State Commun., 7: 299-300(Feb. 1969).

Superconducting transitions were found for hexagonal $K_xReO_3$ ($a = 7.335$ Å, $c = 7.480$ Å, $x \sim 0.3$) and tetragonal $K_xMoO_3$ ($a = 12.36$ Å, $c = 3.86$ Å, $x \sim 0.5$) at 3.6° and 4.2°K, respectively. No superconducting transitions were found for the cubic bronzes $Na_xMoO_3$, $K_xMoO_3$, $Na_xReO_3$, or $ReO_3$ down to 1.3°K. (auth) (UK)

**18558** AMPLITUDE DEPENDENCE OF SHEAR-WAVE ATTENUATION NEAR $T_c$ IN INDIUM. Fossheim, K. (Univ., Oslo); Leibowitz, J. R. Phys. Rev., 178: 647-9(Feb. 10, 1969).

In an experimental investigation of the turnoff of shear-wave attenuation near $T_c$ in indium, it was found that the shape of the falloff curve depends on the ultrasonic wave amplitude. Essential agreement is obtained with a theoretical expression derived involving supercritical currents induced by the sound wave near $T_c$. This agreement is consistent with the bulk critical current of the Ginzburg–Landau theory. (auth)

**18559** FLUX-FLOW NOISE IN A TYPE-I SUPERCONDUCTOR. van Gurp, G. J. (Philips' Gloeilampenfabrieken, Eindhoven, Netherlands). Phys. Rev., 178: 650-6(Feb. 10, 1969).

The noise voltage across a current-carrying type-I superconductor is attributed to flux flow. Measurements of power spectra of this flux-flow noise on In–2 at. % Pb foils show that the noise spectrum has a $1/f^{\alpha}$ frequency dependence with $0.5 < \alpha < 1$. This can be accounted for by a model in which the flux moves in a jerky manner because of interaction with immobile normal regions. This causes a distribution of voltage–pulse duration times. It is concluded from the power spectra that the dc voltage V is caused by a flux-flow component and an ohmic-loss voltage in immobile

normal regions. The flux-flow fraction of the dc voltage is found to be a rapidly decreasing universal function of $V/V_n$, where $V_n$ is the normal-state voltage. The size of the moving normal domains is calculated from the noise voltage and the dc voltage, and is shown to increase with field in a range from $10^3\ \phi_0$ to about $10^5\ \phi_0$. At low fields, flux presumably moves as bundles of small flux tubes, as in type-II superconductors. Close to $T_c$ a structure is found in the power spectra which may be associated with the motion of vortex rings. (auth)

**18560** HYSTERESIS IN SUPERCONDUCTING ALLOYS: TEMPERATURE AND FIELD DEPENDENCE OF DISLOCATION PINNING IN NIOBIUM ALLOYS. Fietz, W. A.; Webb, W. W. (Cornell Univ., Ithaca, N. Y.). Phys. Rev., 178: 657-67(Feb. 10, 1969).

Critical current and pinning-force densities in a series of niobium alloys subjected to severe plastic deformation have been determined from measurements of complete hysteretic magnetization curves on alloys with Ginzburg–Landau parameter $\kappa$ between 1.3 and 13 at temperatures from the critical temperature $T_c$ down to 0.14 $T_c$. Systematic scaling rules were found that accurately describe all of the results over the entire range of fields and temperatures. The pinning-force density scales with magnetic induction as a single function of $B/H_{c2}$; it scales with temperature as the $^5/_2$ power of the upper critical field $H_{c2}(T)$, is roughly proportional to $\kappa^{-\gamma}$, where $1 < \gamma < 3$, and is otherwise independent of T. A model for the pinning process that takes into account deformation of the fluxoid lattice by the pinning forces is proposed to account for the observed scaling rules. The results are consistent with a pinning interaction based on a second-order elastic interaction between dislocations and the fluxoid lattice, but other mechanisms are not excluded. Cooperative effects seem to be an essential feature of the pinning process, leading to a dependence of the pinning-force density on the square of the pinning-point strength, and on the arrangement of pinning points. (auth)

**18561** EFFECTIVE MASSES IN Zr-DOPED SUPERCONDUCTING CERAMIC $SrTiO_3$. Eagles, D. M. (Electronics Research Center, Cambridge, Mass.). Phys. Rev., 178: 668-77 (Feb. 10, 1969).

An analysis is made of published experimental results on superconducting transition temperature as a function of carrier concentration and on magnetic field penetration depths in Zr-doped ceramic $SrTiO_3$. From the penetration-depth results it is deduced that the ratio of effective masses $m_3$ and $m_1$ for 3% and 1% of Ti ions replaced by Zr satisfies $(m_3/m_1) \simeq 1.48$ if Zr ions are the main scattering centers. Using a model involving screened electron–electron interaction via intervalley phonons of energy 0.0497 eV modified by intervalley Coulomb repulsion and by intravalley effects, it is shown that the transition-temperature data can be fitted fairly well with mass changes of the above magnitude, provided that the ratio of phonon-induced to Coulomb intervalley interactions is postulated to increase by about 5% for each percent of Zr doping. It is argued that the large mass increases may imply that a crossing of levels associated with small and large mass states is taking place as Zr is added. The possibility of superconductivity at very low carrier concentrations in specimens with 3% Zr content is discussed. (auth)

**18562** GRUENEISEN FUNCTIONS FOR SOME TYPE-I SUPERCONDUCTORS. Munn, R. W. (Univ. of Bristol, Eng.). Phys. Rev., 178: 677-84(Feb. 10, 1969).

The thermal expansion of some type-I superconductors (indium, lead, tantalum, and tin) is discussed thermodynamically in terms of Grüneisen functions, which describe the volume dependence of the entropy. The Grüneisen functions for the normal and superconducting states can be taken to differ only in their electronic components, $\gamma^{es}$ and $\gamma^{en}$. Values of $\gamma^{es}$ obtained from thermal-expansion measurements in the normal state are shown to be more reliable than values obtained from critical-field measurements on superconductors, because the magnetic data are not accurate enough in the limiting low-temperature region determining $\gamma^{es}$. The values of $\gamma^{es}$ for the four metals all appear to be negative, unlike $\gamma^{en}$. Theoretical values of $\gamma^{es}$ calculated using the BCS theory for weak coupling and the similarity principle are consistent with experiment for all the metals except lead. The disagreement for lead is probably due to its particularly strong electron–phonon coupling. According to the theory, the values of $\gamma^{es}$ depend through $d\ln T_c/d\ln V$ on the volume dependence of the electron–phonon interaction, as well as on properties of the normal state. The experimental evidence for significant changes in lattice properties is discussed; such a change appears to be established for indium but not for lead. (auth)

**18563** CRITICAL-FIELD RATIO $H_{c3}/H_{c2}$ FOR PURE SUPERCONDUCTORS OUTSIDE THE LANDAU–GINZBURG REGION. I. $T \simeq 0$°K. Hu, Chia-ren; Korenman, Victor (Univ. of Maryland, College Park). Phys. Rev., 178: 684-95(Feb. 10, 1969).

The nucleation of superconductivity near a sample surface at temperatures outside the Landau–Ginzburg region is studied. A generalized image method is developed to solve for the normal electron temperature Green's function for a semi-infinite sample with a specularly reflective plane boundary in an external magnetic field. Gor'kov's linearized gap equation is then obtained and studied for such a sample geometry. The pair wave function $\Delta$ is found to obey the Landau–Ginzburg boundary condition at all $T < T_c$, even though this boundary condition was originally suggested only for the Landau–Ginzburg region (i.e., when $T_c - T \ll T_c$). However, it is also found that merely adding the boundary condition to the differential equation appropriate to the bulk case does not give the correct solution to the problem, except when $T_c - T \ll T_c$. At $T = 0$°K, the integral gap equation is solved by a variational approach, yielding the critical-field ratio $H_{c3}/H_{c2} \geq 1.925$. This should be compared with Saint-James and de Gennes's result, ~1.7, for T in the Landau–Ginzburg region. The small-T correction to the ratio near $T = 0$°K is found to be proportional to $T^2 \ln T$ with a small coefficient. An upper bound is also found for the $T = 0$°K ratio to be 5.22, which is useful mainly in proving the existence of a ground state, so as to help justify the use of a variational approach. (auth)

**18564** SYMMETRY CONSIDERATIONS IN THE THEORY OF THE UPPER CRITICAL FIELD OF A SUPERCONDUCTOR. Fredkin, D. R.; Beal-Monod, M. T. (Univ. of California, San Diego, La Jolla). Phys. Rev., 178: 696-701(Feb. 10, 1969).

Translational invariance in a uniform magnetic field is discussed and applied to derive a useful exact canonical form for the normal-state one-particle Green's function. The result is used to generalize earlier theories of $H_{c2}(T)$ to high magnetic fields, where Landau levels may be important. It is proved that at a second-order superconductive transition, translational symmetry must be broken. (auth)

**18565** SUPERCONDUCTIVITY AND ELECTRON INTERACTION IN THE 3d BAND. Andres, K.; Bucher, E.; Maita, J. P.; Sherwood, R. C. (Bell Telephone Labs., Murray Hill, N. J.). Phys. Rev., 178: 702-6(Feb. 10, 1969).

The superconducting transition temperatures, electronic specific heats, and magnetic susceptibilities have been measured for the alloy series Cr–V, Cr–Mo, V–Mo, Ru–Fe (hcp), and Ru–Mn (hcp). These data are combined within the framework of current theoretical models, and conclusions are drawn regarding the strength of the electron phonon attraction and electron–electron repulsion in the 3d band. In particular, it is deduced that the superconducting transition temperature of "paramagnetic" Cr would be $\sim 10^{-6}$°K, and that paramagnetic (hcp) Fe and Mn would not be superconducting at any temperature. (auth)

**18566** TUNNELING STUDY OF SUPERCONDUCTIVITY IN Tl–Pb–Bi ALLOYS. Dynes, R. C.; Carbotte, J. P.; Taylor, D. W.; Campbell, C. K. (McMaster Univ., Hamilton, Ont.). Phys. Rev., 178: 713-24(Feb. 10, 1969).

Superconducting characteristics for selected alloys of the fcc Tl–Pb–Bi system have been measured using the technique of single-particle electron tunneling. Also, calculations of the electron–phonon coupling strength and hence the product function $\alpha^2(\omega)F(\omega)$ determining superconductivity in these alloys have been performed. The computations are based on neutron scattering data, an electron–ion pseudopotential form factor adjusted to fit experimental phonon dispersion curves, and a Born–von Kármán force-constant analysis. Through a solution of the Eliashberg gap equations, a critical comparison is made between the calculated $\alpha^2(\omega)F(\omega)$ and the experimentally determined tunneling curves. It is found that, even though fine details of the phonon-spectrum critical points do not always agree, the calculated superconducting energy gap $\Delta_0$ is, in all cases, in good agreement with experiment. Where confidence is felt in the Born–von Kármán analysis, the location of the experimentally determined critical points is in excellent agreement with those calculated from inelastic neutron scattering data, while the relative strengths of these singularities show discrepancies attributed to the alloy nature of the material under study. (auth)

**18567** POSSIBILITY OF OBSERVING EFFECTS OF THE SUPERCONDUCTING TRANSITION ON POSITRON THERMALIZATION IN METALS. Perkins, A.; Woll, E. J. Jr. (McMaster Univ., Hamilton, Ont.). Phys. Rev., 178: 530-6(Feb. 10, 1969).

An investigation is made of the possibility of observing effects of superconductivity on positron thermalization in metals. Energy is calculated as a function of time for a positron which loses energy by exciting quasiparticles out of the BCS ground state of the superconductor. The minimum positron energy observable in

annihilation experiments at low temperature is predicted to change sharply if the metal goes from the superconducting state to the normal state (preferably by applying a magnetic field greater than the critical field). The possible magnitude of the change is estimated to be 6% of the minimum positron energy in the most favorable cases. (auth)

**18568** SUPERHEATING AND SUPERCOOLING IN SINGLE SPHERES OF TIN, INDIUM, AND GOLD-PLATED INDIUM. Feder, Jens; McLachlan, David S. (IBM Zurich Research Lab.). Phys. Rev., 177: 763-76(Jan. 10, 1969).

An experimental study of the superheating and supercooling properties of tin, indium, and gold-plated indium spheres, typically 10 μm in diam, was made. The results are more reliable than those obtained from experiments on powders. The effects of nucleation centers are discussed, and it is shown that in indium, at least, different nucleation centers are active in superheating and supercooling. The effect of nucleation centers vanishes as one approaches $T_c$, where the following values for the Ginzburg–Landau parameter $\kappa$ are obtained: $\kappa_{Sn} = 0.0926 \pm 0.001$ and $\kappa_{In} = 0.00620 \pm 0.001$. The effect of specimen size upon superheating and supercooling is also clearly demonstrated. It is found that gold plating reduces the supercooling field near $T_c$ by a factor of 1.70 (±2%), as predicted by theory. Gold plating affects the superheating field, as a function of temperature, in a manner which is qualitatively predicted by the Ginzburg–Landau theory. (auth)

**18569** CONCERNING CERTAIN FEATURES OF THE STATIONARY JOSEPHSON EFFECT. Galkin, A. A.; Borodai, B. U.; Svistunov, V. M.; Tarasenko, V. N. (Donets Physico-Technical Inst., Kiev). JETP Lett. (USSR) (Engl. Transl.), 8: 318-20 (Nov. 20, 1968).

Translated from Zh. Eksp. Teoret. Fiz., Pis'ma Redaktsiyu, 8: 521-4(Nov. 20, 1968).

Preliminary experimental results on the stationary Josephson effect are reported, which apparently offer evidence of the influence of fluctuations on the superconducting tunneling. High-resistance (0.05 to 0.1 ohm-mm$^2$) Pb/insulator/Pb tunnel junctions with film thickness ~1300 Å were investigated. For all the samples, the width of the junction was small compared with double the Josephson depth of penetration ($2\lambda_j > W$), i.e., the distribution of magnetic field and of the current over the sample was homogeneous. The maximum value of the observed superconducting current was 6 to 20% of theoretical. The behavior of the critical Josephson current in magnetic fields was investigated. Unlike the low-resistance samples (~0.01 ohm-mm$^2$), two types of dependences were observed. (1) In certain fields, the superconducting "direct" current flows at a finite voltage across the barrier, retaining the periodic dependence on the field. (2) The Josephson current exhibits no oscillatory dependence on the magnetic field. (M.H.R.)

# Plasma and Thermonuclear Physics

*Refer also to abstracts 17663–17665.*

**18570** (AED-C-3-26) PLASMA PHYSICS INDEX. EXPERIMENTAL AND THEORETICAL PLASMA PHYSICS. Bibliography; Author Index; Subject Index. Volume 3, No. 11. Hilsenbeck, D. (comp.) (Zentralstelle fuer Atomkernenergie-Dokumentation, Frankfurt am Main (West Germany)). 1968. 234p. Dep.

473 papers on various aspects of plasma physics are listed. Subject and author indexes are included. (M.O.W.)

**18571** (CONF-680113-(Vol.1)) 2nd INTERNATIONAL CONFERENCE ON THE INTERACTIONS BETWEEN OSCILLATING FIELDS AND PLASMAS, SACLAY, FRANCE, JANUARY 15–19, 1968. VOLUME I. (Institut National des Sciences et Techniques Nucleaires, Saclay (France)). 510p. (In French and English). Dep.

Separate abstracts were prepared for the 23 individual papers. (M.O.W.)

*For abstracts of individual papers see: 18576–18585, 18612, 18620–18623, 18643, and 18683–18689.*

**18572** (CONF-680113-(Vol.2)) 2nd INTERNATIONAL CONFERENCE ON THE INTERACTIONS BETWEEN OSCILLATING FIELDS AND PLASMAS, SACLAY, FRANCE, JANUARY 15–19, 1968. VOLUME II. ACCELERATION, REFLECTION, AND ACCUMULATION OF PLASMAS BY HF FIELDS ALONE OR ASSOCIATED WITH A STATIC MAGNETIC FIELD. (Institut National des Sciences et Techniques Nucleaires, Saclay (France)). 297p. (In French and English). Dep.

Separate abstracts were prepared for the 13 individual papers. (M.O.W.)

*For abstracts of individual papers see: 18586, 18613, 18624–18628, 18644–18647, 18665, and 18690.*

**18573** (NP-17775) SIXTEENTH SIX-MONTHLY PROGRESS REPORT [ON PLASMA PHYSICS], JULY 1–DECEMBER 31, 1968. (Sydney Univ. (Australia). School of Physics). 8p. (PR-16). Dep.

A very brief outline of research carried out at Sydney during this period is given. The research was done on the SUPPER devices and laser devices. (M.O.W.)

## Confinement and Heating

*Refer also to abstracts 17839, 18621, 18684, 19086, and 19097.*

**18574** (AD-673660) ELECTRICAL PROTECTION OF CLOSED SOLENOID. Burchenko, P. Ya.; Volko, E. D.; Georgievskii, A. V.; Ziser, V. E.; Kitaevskii, L. Kh. Translated from pp 3-6 of Elektrozashchita Zamknutogo Solenoida, Kharkov, 1966. 10p. (FTD-MT-67-85). CFSTI.

Large thermonuclear installations commonly have closed solenoid magnetic systems for confinement of plasma. When trouble occurs in the solenoid circuit destruction of the magnetic system and allied assemblies may result. Hence the problem of reliable protection of the solenoid becomes urgent. The authors propose a method and describe an effective device for electrical protection of a closed solenoid. (USGRDR)

**18575** (BNL-50120(Pt.2), pp 713-23) ASTRON LINEAR ACCELERATOR. Beal, J. W. (California Univ., Livermore. Lawrence Radiation Lab.).

The design features of a linear induction electron accelerator, for use in experiments with the Astron, are described. The parameters of the accelerator are: beam energy—4.23 MeV, beam current—1000 A, beam pulse length—0.3 μsec. The design beam emittance is 10π mr-cm in both transverse dimensions and an energy spread of 2% full-width-half-maximum. The acceleration consists of an increasing gradient gun with an output beam energy of 562 keV, followed by two constant gradient injector sections each adding 220 keV to the beam energy. The remainder of the accelerator is made up of 17 identical accelerator sections, each supplying 190 keV to the beam energy. Solenoidal focusing magnets are positioned with a particular magnetic field strength to provide phase-space matching between the various sections of the accelerator. Steering magnets are placed so as to compensate for the earth ambient magnetic field and possible stray fields. (auth)

**18576** (CONF-680113-(Vol.1), pp 11-48) FORMATION AND HEATING OF A PLASMA IN A MAGNETIC FIELD UNDER THE ACTION OF HF WAVES. Golant, V. E. (Akademiya Nauk SSSR, Leningrad. Fiziko-Tekhnicheskii Institut). (In French).

This report summarizes the research carried out in the Ioffe Physico-Technical Institute. Experiments on the formation and heating of a plasma by a uhf field, the characteristics of plasma created under the action of uhf power, the absorption of uhf waves in a plasma, and the independent heating of electrons and ions of a plasma in a magnetic trap are considered. (J.F.P.)

**18577** (CONF-680113-(Vol.1), pp 87-100) NONRESONANT MICROWAVE HEATING OF PLASMA ELECTRONS. Wort, D. J. H. (United Kingdom Atomic Energy Authority, Abingdon (England). Culham Lab.).

A heating system which is to be of general application to any laboratory plasma must not depend on a resonant phenomenon. Heating without gross disturbance of the plasma can only be carried out by collisional absorption, and for this to be appreciable requires that a wave with low group velocity be launched in the plasma. Such a wave has been found, and it may be launched by progressive coupling from a slow wave structure outside the plasma boundary. Coupling coefficients for TE and TM structures have been computed, and it is found that a slight helicity of the confining magnetic field can considerably enhance the coupling. At electron temperatures of a few hundred volts, absorption by Landau damping becomes important. (auth)

**18578** (CONF-680113-(Vol.1), pp 161-78) ELECTRON-CYCLOTRON HEATING BY 8-mm MICROWAVE POWER IN THE MAGNETIC FACILITY ELMO. Dandl, R. A.; Eason, H. O.; Edmonds, P. H.; England, A. C. (Oak Ridge National Lab., Tenn.).

Recent experiments in ELMO employing continuous-wave microwave power in a high mode cavity have shown several surprising features. The high-energy electrons in which most of the energy resides are found primarily in an annulus near the cavity walls and have sufficient density to cause an approximately 40% depression of the vacuum field. The electron-cyclotron plasma is created in a 2:1 mirror field with up to 2 kW of 8-mm microwave power. The belt of electrons from 3 to 4 cm in radial extent at a radius of

approximately 9 cm creates the field depression. Flux coils placed around the microwave cavity indicate up to 60,000 maxwells flux change when the microwave power is turned off. A flux coil inserted into the center of the cavity shows a field increase when the microwave power is on, indicating that the plasma is in the form of an annulus and that small energetic electron orbits (plasma) rather than large concentric orbits (ring currents) are responsible for the manifest energy parameters, such as high $\beta$ and large Coulomb dissociation neutron flux. Some of the effect, however, is apparently due to drift currents around the axis. Neutron production from Coulomb dissociation of deuterium allows a measure of the number of electrons above 2.2 MeV, thereby providing distribution function information. Radial and axial profiles of the high $\beta$ belt have been computed from spatially dependent diamagnetic measurements. Comparison of the total stored energy measured diamagnetically with the energy resident in the electrons that produce neutrons indicates the average electron temperature to be well below 2.2 MeV. (auth)

**18579** (CONF-680113-(Vol.1), pp 203-34) TURBULENT HEATING IN A PLASMA BY AN ELECTRIC CURRENT. Zavoiskii, E. K.; Rudakov, L. I.; Fanchenko, S. D. (Akademiya Nauk SSSR, Moscow. Institut Atomnoi Energii). (In French).

A discussion is given of experiments for the turbulence heating in a plasma, the study of current instabilities, and theory of turbulent heating in a plasma. (J.F.P.)

**18580** (CONF-680113-(Vol.1), pp 235-43) NONLINEAR THEORY OF TURBULENT HEATING OF A PLASMA BY LOW-FREQUENCY ELECTROMAGNETIC WAVES. Sizonenko, V. L.; Stepanov, K. N.; Teichmann, I. (Akademiya Nauk Ukrainskoi SSR, Kharkov. Fiziko-Tekhnicheskii Institut). (In French).

It is shown that the rapid turbulent heating of the ion component of a plasma by the electric field of an ion-cyclotron or magneto-acoustic wave is the consequence of the development of an electro-acoustic instability. (J.F.P.)

**18581** (CONF-680113-(Vol.1), pp 289-318) PLASMA HEATING BY STRONG INTERACTION WITH AN ELECTRON BEAM IN A MAGNETIC-MIRROR CONFIGURATION. Bottiglioni, F.; Coutant, J.; Gadda, E.; Prevot, F. (Commissariat a l'Energie Atomique, Fontenay-aux-Roses (France). Centre d'Etudes Nucleaires). (In French).

The primary objective was to determine how the macroscopic parameters such as gas pressure, magnetic field intensity, mirror relations, and energy and intensity of the electron beam effect the appearance of the strong interaction and how, when that interaction is produced, they operate on the properties of the formed plasma. (J.F.P.)

**18582** (CONF-680113-(Vol.1), pp 343-78) ION CYCLOTRON RESONANCE HEATING OF THE QP PLASMA. Matsuura, Kiyokata; Sato, Teruyuki; Miyahara, Akira; Nagao, Shigeo (Nagoya Univ. (Japan). Inst. of Plasma Physics).

The investigations concerned the dispersion relations of electrostatic ion cyclotron waves, excitation and propagation of ion cyclotron waves, and plasma loading under Stix-type coil with the plasma produced in the QP machine. The feeding system of the Stix-coil is also discussed. (M.O.W.)

**18583** (CONF-680113-(Vol.1), pp 391-406) MODE TRACK SYNCHRONISM: NEW PRINCIPLE OF PLASMA HEATING AND ACCELERATION. Motz, H.

A method for investigating the interaction between waves propagating in a plasma-filled waveguide and particles in helical motion along the waveguide axis is discussed. The particles may be ions or electrons with a thermal velocity in the axial direction eventually. (M.O.W.)

**18584** (CONF-680113-(Vol.1), pp 407-28) ANISOTROPIC INSTABILITY OF THE RATE OF PLASMA HEATING IN AN ADIABATIC TRAP AT ELECTRON CYCLOTRON RESONANCE. Alikaev, V. V.; Glagolev, V. M.; Morosov, S. A. (Akademiya Nauk SSSR, Moscow. Institut Atomnoi Energii). (In French).

A later and more comprehensive treatment of this subject appears (in English) in Plasma Phys., 10: 753-74(Aug. 1968). An abstract appears in NSA 23: 10691. (T.S.S.)

**18585** (CONF-680113-(Vol.1), pp 485-90) MAGNETIC PUMPING OF AN INHOMOGENEOUS COLLISIONAL PLASMA. Nemov, V. V.; Stepanov, K. N. (Akademiya Nauk Ukrainskoi SSR, Kharkov. Fiziko-Tekhnicheskii Institut). (In French).

The authors draw from earlier works by Dawson and Uman (Nuclear Fusion, 5: 242(1965)) and Dolgopolov and Stepanov (Nuclear Fusion, 3: 205(1963)) in discussing heating in a cylindrical inhomogeneous plasma. Dawson and Uman calculated heating rates in a cylindrical homogeneous plasma for different values of density, temperature, and frequency, using two-component MHD equations. When heating times are very great, the "turbulent heating" methods appear satisfactory for effecting rapid energy transfer from external sources of plasma. (T.S.S.)

**18586** (CONF-680113-(Vol.2), pp 677-99) CONFINEMENT OF ENERGETIC PLASMA IN A PULSED MAGNETIC BOTTLE WITH THE AID OF A PLEIADE-TYPE ACCELERATOR. Brunet, A.; Geller, R.; Jacquot, B. (Commissariat a l'Energie Atomique, Saclay (France). Centre d'Etudes Nucleaires). (In French).

The experimental results obtained with a device of the Pléiade type when the accelerated plasma jet encounters either a continuous or a pulsed magnetic mirror at 70 $\mu$s are explained. In the first case it is shown that instabilities destroy the ionic acceleration whereas, in the second case, one can obtain an accumulation of energetic particles, limited essentially by the charge exchange of the ions. (J.F.P.)

**18587** INVESTIGATION OF ENERGY LOSSES AND OF THE EFFICIENCY OF TURBULENT HEATING OF A PLASMA BY A CURRENT. Kalinin, Yu. G.; Lin, D. N.; Ryutov, V. D.; Skoryupin, V. A. Zh. Eksp. Teor. Fiz., 56: 462-71(Feb. 1969). (In Russian).

The efficiency of turbulent heating and of energy losses of a plasma in an open trap was investigated. It is shown that the efficiency of the heating increases with growth of the magnetic field strength in which the heating occurs and with growth of the initial density of the charged particles in the trap. The maximum heating efficiency attained in the experiments is 25%. The authors ascribe the plasma heating to development of ion-acoustic instability in the plasma. (auth)

**18588** STELLARATOR HAVING MULTIPOLE MAGNETS. Cornish, C. D. (to United States Atomic Energy Commission). U. S. Patent 3,433,705. Mar. 18, 1969.

This patent relates to specific, stabilized, superconductors for producing strong, accurate, persistent, multipole Ioffe, minimum-$\beta$, and axial magnetic fields having concentric field lines for confining high-temperature plasmas, and for confining the magnetic field lines themselves for producing a decreasing plasma density gradient radially outwardly along a stellarator axis. These specific superconductors, which form stabilized multipole superconductor magnets, are directly related to the superconductors for producing practical multipole magnets for confining high-energy charged-particle beams, and take advantage not only of the techniques and problems common to both accelerators and thermonuclear reactors but also analogous topologies therein. To this end, in one embodiment, a stellarator is provided having periodic stages of quadrupole, superconducting magnets that are rotated 90° between focusing and defocusing positions. Also, provision is made for injection of particles between quadrupoles that incorporate specific superconductor ribbon having a normal resistance conductor thereon for stabilizing the superconductor ribbon against flux jumps at high persistent fields. (AEC)

**18589** PRELIMINARY EXPERIMENT ON THE PLASMA CONFINEMENT IN THE HELIOTRON P FIELD. PART I. Mohri, Akihiro; Matsuda, Shinzaburo (Kyoto Univ.). Kakuyugo Kenkyu, 22: 245-68(Feb. 1969). (In Japanese).

A magnetic mirror field having a minimum average B configuration can be produced by the combination of a usual mirror field and the magnetic field generated by a current-carrying ring, which is put on the midplane of the mirror field and encircles the axis. This field configuration forms a fundamental unit of the Heliotron-P field. The bottom of the magnetic well is on the separatrix, which is the surface woven by the lines of force passing the null-field circle of this field. The plasma is axially injected into the field through a small aperture limiter near the axis or through a circular narrow slit outside the separatrix. In both cases, the injected plasma quickly fills up the magnetic well due to the flute instability. This phenomenon bears the experimental evidence of the minimum average B field. After 250 $\mu$sec from the injection, the plasma is very quiescent and its radial density profile becomes flat across the wide region of the plasma column and it falls rapidly at the periphery. The density decays with time, keeping this profile. In this stage, the overall decay time of the plasma density is about 500 $\mu$sec, which corresponds to 16 times the Bohm confinement time $\tau_B$. The net radial loss time is longer than 45 $\tau_B$, which is inferred from direct measurements of the mirror end loss and the losses towards the ring and its supports. The electron temperature remains almost constant at 11 eV. (NSA of Japan)

**18590** PLASMA HEATING BY MAGNETO-ACOUSTIC WAVES. Kovan, I. A.; Kozorovitskii, L. L.; Podgornyi, I. M.; Rusanov, V. D.; Smirnov, V. P.; Spektor, A. M.; Frank-Kamenetskii, D. A. At. Energ. (USSR), 25: 503-6(1968). (In Russian).

Ion heating by magnetoacoustic resonance was investigated. The experiments were conducted in hydrogen plasma with the density of 1 to $2 \times 10^{13}$ $cm^{-3}$ in a constant homogeneous magnetic field with strength of 2 kG. The plasma wave was excited by the hf generator of 300 kW and frequency of 21 Mc. The magnetic probe measurements demonstrated that magnetoacoustic resonance was excited at the lowest mode oscillations. The electron temperature was estimated from the spectral line measurements. It is shown that the diamagnetic effect in the plasma is completely determined by the ion pressure. The ion heating by magnetoacoustic waves was independently confirmed by direct measurements of the Doppler line broadening. The maximum plasma pressure was equal to $2 \times 10^{15}$ $eV \cdot cm^{-3}$ and the ion temperature was more than 100 eV. Propagation and absorption of nonlinear oblique magnetoacoustic waves were studied in a magnetic trap. The waves were generated by means of a narrow coil. The coil current wave in the plasma was an attenuated sinusoid with a frequency of 12 Mc. The strength of the ac magnetic field was up to 2000 Oe. The constant field was varied from 250 up to 2000 Oe., the concentration being within the range of $(0.4 \text{ to } 7) \times 10^{13}$ $cm^{-3}$. The $H_z$, $H_\phi$, and $H_{Br}$ field components were measured by means of magnetic probes with oscillations at the wave front. The wave energy dissipation with collisionless. The behavior of uhf and x radiations was in agreement with the assumption of current instability excitation. The electron temperature was raised up to 300 eV. (auth)

**18591** CONTAINMENT TIME OF PLASMA IN THE SM MAGNETIC TRAP. Sadowski, M. (Inst. of Nuclear Research, Swierk, Poland). Phys. Lett., 28A: 626-7(Feb. 10, 1969).

Results of investigations of plasma containment in the spherical multipole magnetic field are presented. The plasma lifetime in the SM trap is found to be approximately 3 times that in the cusp trap investigated, with the other experimental conditions identical. (auth)

**18592** CONCERNING ONE POSSIBILITY OF ANOMALOUSLY RAPID TURBULENT HEATING OF PLASMA IONS. Sizonenko, V. L.; Stepanov, K. N. (Physico-Technical Inst., Moscow). JETP Lett. (USSR) (Engl. Transl.), 8: 363-6(Nov. 20, 1968).

Translated from Zh. Eksp. Teoret. Fiz., Pis'ma Redaktsiyu, 8: 592-5(Nov. 20, 1968).

The stability of a plasma consisting of a mixture of ions of two types moving perpendicular to the magnetic field in an electric field of a low-frequency electromagnetic wave is considered. The opposing ion currents can arise also in a collisionless shock wave. The ion–ion instability resulting in this case can play an important role in the formation of the wave front and in the heating of the ions. It is shown that in a three-component plasma there exist, besides the well known hydrodynamic ion–ion instability also other types of ion–ion instabilities, connected with the excitation of strongly damped modes, when the relative velocity of the ionic components is equal to zero. (M.O.W.)

**18593** THE OPTIMUM CONFIGURATION OF THE PERIODIC QUADRUPOLE MINIMUM-$\bar{B}$ FIELD. Sometani, Taro; Yamamoto, Kenzo (Nagoya Univ., Japan). J. Phys. Soc. Jap., 26: 781-4 (Mar. 1969).

A variational problem with respect to a functional comprising two argument functions is solved. In this problem, the configuration of the periodic quadrupole min $\bar{B}$ field is optimized in a sense when the ratio of the maximum to the minimum distance of a line of force from the axis of a cylindrical geometry is kept within a limit. The two stationary functions concerned have a singular point, respectively, and minimize the functional only in that left side region of the singular point in which the integrand of the functional is positive. (auth)

**18594** PLASMA DIFFUSION IN A TOROIDAL STELLARATOR. Galeev, A. A. (Inst. for Nuclear Physics, Novosibirsk, USSR); Sagdeev, R. Z.; Furth, H. P.; Rosenbluth, M. N. Phys. Rev. Lett., 22: 511-14(Mar. 17, 1969).

Collisional diffusion in long-mean-free-path, geometrically nonsymmetric regimes is characterized by Bohm-like scaling laws. A variational principle is found for calculation of diffusion constants. (auth)

**18595** HEATING OF PLASMA IONS BY AN EXTERNAL STOCHASTIC FIELD. Shvets, O. M.; Kalinichenko, S. S.; Kurilko, V. I.; Miroshinchenko, G. A. (Inst. of Physics and Tech., Kiev). JETP Lett. (USSR) (Engl. Transl.), 8: 388-90(Dec. 5, 1968).

Translated from Zh. Eksp. Teor. Fiz., Pis'ma Redaktsiyu, 8: 629-32(Dec. 5, 1968).

The experimental investigations of the stochastic heating of the ions were made with the "Vikhr'" setup with a glass chamber. The plasma was produced by the same stochastic hf field used for the heating. The initial noise source was a gas-filled SG3P ballast tube, the noise spectrum of which lies in the frequency range 0 to 1.5 MHz. This spectrum was transformed with the aid of a ring-type balanced modulator into the employed frequency range, was amplified, and was fed to the output power amplifier (OPA). The OPA load was a resonant circuit loaded by the introduced plasma resistance. The operating frequency band was regulated both at the input and output of the OPA by decreasing the coupling of the output resonant circuit with the plasma. The band was measured in the continuous mode by means of an S4-8 spectrum analyzer, with a resistance equal to the equivalent plasma resistance connected to the resonant circuit. When working with the plasma, the OPA was used in the pulsed mode. The experiments were performed at operating bandwidths $\Delta f = 200$ kHz and $\Delta f = 80$ kHz in the 2 MHz region, corresponding to the condition of excitation of ion-cyclotron waves ($\omega \leq \omega_{ci}$). The power introduced into the plasma was measured by the equivalent-resistance method, and the hf voltage by the square-law detector. (TSS)

**18596** TURBULENT HEATING IN A TOROIDAL SYSTEM WITH A CURRENT. Balakhanov, V. Ya.; Zhivotov, V. K.; Zinov'ev, O. A.; Milnikov, G. D.; Rusanov, V. D.; Titov, A. V. Zh. Eksp. Teor. Fiz., 56: 439–43(Feb. 1969). (In Russian).

Turbulent heating in a toroidal system with a current is investigated experimentally for the case when a vortex high-frequency emf parallel to the magnetic field is produced by discharge of a condenser onto the copper case enclosing the ceramic vacuum chamber. Diamagnetism of the plasma, the behavior of the high-frequency voltage and current and the radiation from the plasma in the 4- to 16-mm range were the main objectives of the investigation. The maximal value of nT (n is the concentration and T temperature of the plasma) attained during heating of the plasma was $3 \times 10^{16}$ $eV \cdot cm^{-3}$ for a concentration of $(2 \text{ to } 4) \times 10^{13}$ $cm^{-3}$, the magnitude of the anomalous resistance in this case being of the order of 6 ohms. The plasma radiation is modulated by the hf current and is maximum at $\omega_0$. The nature of the emission spectrum qualitatively indicates excitation of Langmuir and ion–acoustic oscillations. It is suggested that the heating method described here may be successfully employed in toroidal arrangements. (auth)

## Diagnostics

*Refer also to abstract 18637.*

**18597** (AD–671493) VELOCITY DETERMINATION BY THE MEASUREMENT OF THE INDUCED POTENTIAL IN A NONUNIFORM PLASMA FLOW. Technical report. Dove, W. F.; Kunkel, W. B.; Talbot, L. (California Univ., Berkeley. Div. of Aeronautical Sciences). May 1968. 162p. (AS–68–3). CFSTI.

The validity of the equation for the determination of the velocity of an ionized gas by the measurement of induced potential differences was experimentally and theoretically investigated. The experimental program provides the results of a series of measurements of the change in induced potential in a low-density arc-heated argon plasma jet for a given increment in the externally applied magnetic induction field. A theoretical prediction for the induced potential is developed from Maxwell's equations for a continuous media with an assumed nonuniform velocity field. The influence of the finite extent of the magnetic field is explicitly formulated, and the influence of various constitutive relations between current and potential gradients is investigated. The majority of the results were obtained using a simple Ohm's Law for nonrelativistic velocities; however, two exact solutions for induced potential were obtained for an anisotropic electric conductivity. The influence of other mechanisms such as induced temperature gradients on charge transport through coupling by Joule heating are explored. The data obtained in the experimental program are interpreted in terms of the results of the theoretical analysis. A procedure for determining the velocity is formulated in terms of several universal functions of the experimental observables. (auth) (USGRDR)

**18598** (AD–673699) MERCURY ARC PLASMA TUBE DIAGNOSIS STUDY. PART I. LANGMUIR PROBE STUDY. Vault, William L.; Rosado, John A. (Harry Diamond Labs., Washington, D. C.). June 1968. 35p. (HDL-TR-1394). CFSTI.

A Langmuir probe analysis of the plasmas generated by the HDL Mercury arc facility was performed to determine electron density and temperature. The electron temperature data are presented in tabular form as a function of the discharge current. Electron density profiles were constructed from the electron density data and are given in graphic form. A review of the theory of positive ion collection by a negative probe in plasma is also included. (auth) (USGRDR)

**18599** (AD–674614) ELECTRIC ARCS IN TURBULENT FLOWS. III. Interim Report, February 1967–March 1968.

Frind, Gerhard; Damsky, Ben Lee (General Electric Co., Philadelphia, Pa. Missile and Space Div.). Apr. 1968. Contract F33615-67-C-1374. 63p. (ARL-68-0067). CFSTI.

Work is reported on the development of methods to measure arc temperature, axial pressure gradient, plasma flow velocity, and radiative heat flux in long cylindrical turbulent arcs. Axis temperature and radial temperature distributions of laminar and turbulent 50-A nitrogen arcs of 11.2-atm pressure were found to be of similar size, with some reservation about the accuracy of the "side-on" turbulent temperature measurement. The problem of measuring average turbulent arc temperatures was discussed; measurements in "end-on" observation and the use of the Milne-Lorentz method appear to give better results than "side-on" observation of absolute line intensities. Measurements of the pressure gradient in a 11.2 atm., 125 A argon arc show a 1.8 power dependence of pressure gradient on flow rate, indicating that this relationship, well known from cold flow experiments, also holds under the conditions of the experimental arc temperatures. Plasma velocities were measured by time-sequential photography of the turbulent arc structure. (auth) (USGRDR)

**18600** (LRP-39/68) SPECTROSCOPIC OBSERVATION OF IMPURITIES IN A PLASMA PULSE AND ION TEMPERATURE MEASUREMENTS. Berney, A. (Centre de Recherches en Physique des Plasmas, Lausanne (Switzerland)). Dec. 1968. 59p. (In French). Dep.

Spectroscopic measurements were made in a plasma produced by an axial preionization discharge followed by a rf rotating magnetic field pinch. General observations about impurities are presented, concerning both discharges. Ion temperature measurements in the preionized plasma are reported. Spectral lines of $O^+$, $Ar^+$, $N^+$ and $N^{++}$ were analyzed with a multichannel Fabry-Perot interferometer. The lines widths and shifts are related to the ion temperatures of the different species and to large-scale turbulence motions in the plasma. (auth)

**18601** (NP-17785) DETERMINATION OF THE LOCAL VALUES OF PLASMA PARAMETERS BY THE ENERGY ABSORPTION OF A REFRACTING MICROWAVE BEAM. No. 12. Dushin, L. A.; Pimkin, V. A.; Skibenko, A. I.; Fomin, I. P. (Akademiya Nauk Ukrainskoi SSR, Kharkov. Fiziko-Tekhnicheskii Institut). 1968. 14p. (In Russian). Dep.

An experimental determination of the electron density and temperature distribution by the radius of the pulsed reflecting discharge in a decaying plasma is described. A method of microwave probing of the plasma cylinder in the cross section at different angles to the interface was used in the measurements. (JPRS)

**18602** LANGMUIR PARADOX. Benke, Yu.; Kagan, Yu. M.; Milenin, V. M. (Leningrad State Univ.). Zh. Tekh. Fiz., 38: 1197-1200(July 1968). (In Russian).

A number of mechanisms that potentially can explain the Langmuir paradox are discussed. The Langmuir paradox is the finding that the Maxwellian distribution of electrons in low-pressure discharges cannot be explained by the theory of binary collisions. Previous attempts to resolve the paradox are discussed. A study was made to substantiate the existence of the Maxwellian distribution in the positive column of a low-pressure discharge. It is shown that such distributions exist for electrons even with energies higher than ionization energy provided the inelastic collision frequency $f_i$ is smaller than electron-wall collision frequency. When at higher pressure this inequality is reversed, a substantial deficiency of electrons in the high-energy tail of the distribution is found. Noting that the addition of inert gas up to levels such that electron-inert atom collision frequency exceeded $f_i$ had the same effect as the presence of the walls, it is concluded that Maxwellization at the walls is an effective mechanism. (ATD)

**18603** ENERGY DISTRIBUTION OF ELECTRONS AND THEIR CONCENTRATION IN A LOW TEMPERATURE PLASMA. Pushkarev, O. E. (Inst. of Engineering Thermophysics, Kiev). Zh. Eksp. Teor. Fiz., 56: 551-62(Feb. 1969). (In Russian).

The effect of resonance radiation yield on the electron energy distribution and electron concentration in a low-temperature plasma is investigated. The kinetic equation is solved by taking into account inelastic collisions of the first and second kind in the case of a high electron concentration. The corresponding magnitude of the deviation of the system from the equilibrium state is determined for relatively small or large resonance radiation yields. The problem is also solved in the converse case of a small electron concentration in a strong electric field. (auth)

**18604** METHODS OF PLASMA DIAGNOSTICS. PART IIa. Somesan, Maria (Inst. of Physics, Bucharest). Stud. Cercet. Fiz., 20: 847-84(1968). (In Rumanian).

Diagnostic techniques based on operations in the microwave range are becoming increasingly important for the study of plasma because they are nondestructive in character and possess a high sensitivity. Study of the propagation properties of the waves in the presence of plasma and of the radiation characteristics of the microwaves of the plasma itself yield valuable information in this respect. The specific features of the propagation phenomena of the microwaves are due to the strong interactions between the externally induced oscillations and the plasma's own oscillations. Although no theory has been developed as yet to account for all of the interaction phenomena involving the field of oscillations and the free particles, in the plasma, convenient approximation methods have been developed on the basis of simplying assumptions. Applicability of wave guides for plasma diagnostics is similar to that of resonant cavities, involving attenuation and phase shift measurements, attributable to the presence of plasma during the propagation of the wave through the waveguide. The Langmuir probe technique is also examined. (TTT)

**18605** MICROWAVE DIAGNOSTICS OF LASER PRODUCED ALUMINUM PLASMAS. Pack, J. L.; George, T. V.; Engelhardt, A. G. (Westinghouse Research Labs., Pittsburgh). Phys. Fluids, 12: 469-71(Feb. 1969).

A focused laser beam has produced plasmas from single aluminum spheres 50 to 150 $\mu$ in radius. Microwave studies determined the expansion velocity at 300 nsec and the average electron density between 1 and 6 $\mu$sec. (auth)

**18606** PLASMA DENSITY MEASUREMENT BY ELECTROMAGNETIC WAVE PROPAGATION AT SMALL ANGLES TO MAGNETIC FIELD. Bachynski, M. P.; Gibbs, B. W. (RCA Victor Research Labs., Montreal). Phys. Fluids, 12: 467-8(Feb. 1969).

The propagation of a left-circularly polarized plane wave in a plasma at small angles to the static magnetic field direction shows a sharp "dip" in the wave amplitude when the plasma frequency equals the wave frequency. (auth)

**18607** CONTINUUM THEORY OF COOLED SPHERICAL ELECTROSTATIC PROBES. Thomas, D. Lyddon (Central Electricity Research Labs., Leatherhead, Eng.). Phys. Fluids, 12: 356-60(Feb. 1969).

The continuum theory of Su and Lam is extended to cover the case of a probe cooler than the gas in which it is immersed. It is assumed that the equilibrium temperature distribution is set up around the probe, and that the gas properties vary as predicted by simple kinetic theory. It is found that the highly negative probe problem can be solved in a manner similar to that adopted by Su and Lam, that the effect of the temperature distribution on the current-voltage characteristics is very slight, and that an approximate expression given by Su and Lam is more accurate for a cold probe than for one at the gas temperature. (auth)

**18608** PROPERTIES OF AN ARGON LASER IN THE SCHLIEREN STUDY OF GAS FLOW WITHIN AN ELECTRIC ARC OR PLASMA. Webster, J. M. (Central Electricity Generating Board, London); Graham, R. W. J. Photogr. Sci., 16: 49-56 (Mar.-Apr. 1968).

A diagnostic technique is suggested which will permit studies of gas flow within power arcs or plasmas by the use of a schlieren system. Experimental evidence is given showing that high-speed ($10^7$ p.p.s.) Kine schlieren photography can be undertaken with a gas laser of moderate power output. Both multiphase and uniphase modes of operation are considered, and a simple form of exposure assessment is given which relates spectral sensitivity ($S_\lambda$) of a photographic material with the laser beam in use. A possible method of obtaining pulsed amplification by the application of a solenoid is discussed. (auth)

**18609** APPLICATION OF CARBON DIOXIDE LASER INTERFEROMETER TO MEASUREMENT OF PLASMA ELECTRON DENSITY. Miyoshi, Syoichi; Shiobara, Shinji; Shimizu, Tadao (Inst. of Physical and Chemical Research, Tokyo). Jap. J. Appl. Phys., 8: 383-7(Mar. 1969).

The electron density of transient plasma is measured with a Michelson-type $CO_2$ laser interferometer. The frequency and amplitude stabilities of the laser oscillation and the spatial distribution of the laser beam are investigated. The directivity of the laser beam is in accord with the classical diffraction theory in the Fraunhofer region. Although the experimental apparatus is not stabilized against the ambient temperature change, the error of measurement coming from fluctuation of the interference signal is less than 0.1 fringe, which corresponds to the phase shift produced by a plasma of electron density of $3 \times 10^{14}$ $cm^{-3}$ and of length of 3 cm. (auth)

**18610** COOPERATIVE LASER SCATTERING AT 90° FROM A COLD DENSE PLASMA. Martone, M.; Segre, S. E. (CNEN, Frascati, Italy). Phys. Lett., 28A: 610-11(Feb. 10, 1969).

In a 90° scattering experiment the electron satellite was resolved and the ratio of the energy in the ion feature and in the satellites was measured. From the spectrum, the plasma density and temperature were determined. (auth)

**18611** X-RAY DETECTOR SYSTEM FOR DETERMINING PLASMA ELECTRON TEMPERATURE. Elton, Raymond C. (to Secretary of the Navy). U. S. Patent 3,432,659. Filed May 26, 1966.

This device is directed to a system for simultaneously measuring x rays emitted from a high-temperature plasma source by using four separate measuring channels, each of which has a thin metallic foil through which the x rays pass. The four channels are positioned about the axis of the system such that x rays may also pass through the device along the axis to be detected by a vacuum spectrograph or a mass spectrometer. The radiation passes through each of the foils striking a scintillator material which gives off light that is detected by separate photo detectors. The foils are mounted onto a rotatable wheel that contains twelve different foils, thus each detector may be used to detect x rays that pass through one each of three foils that may be rotated into place. The x ray signals are compared to determine the electron temperature of a plasma above two million degrees. (Offic. Gaz.)

## *Kinetics (General)*

*Refer also to abstract 19093.*

**18612** (CONF-680113-(Vol.1), pp 245-87) ANOMALOUS HIGH-FREQUENCY CONDUCTIVITY OF A TURBULENT PLASMA. Bertotti, B. (Comitato Nazionale per l'Energia Nucleare, Frascati (Italy). Laboratorio Gas Ionizzati). Messina Univ. (Italy). Istituto di Fisica); De Barbieri, O. (Milan Univ. (Italy). Isiituto di Scienze Fisiche. Consiglio Nazionale delle Ricerche, Milan (Italy)).

The anomalous high-frequency conductivity, arising from partial-wave interactions, is studied in a many-species turbulent plasma with no external magnetic field. The calculation is made by using the full three-dimensional model of the quasi-linear theory of plasma turbulence for a wide range of frequencies embracing the electron plasma frequency. It is found that the conductivity tensor is anisotropic and slowly time dependent; this reflects the slow time dependence and the anisotropic character of the distribution functions of the velocities of the particles. It is also found that there is a very narrow range of frequencies (just above the electron plasma frequency) for which the components of the conductivity tensor are negative. The particular case of the two-stream instability is examined in detail. The anisotropic character of the components of the conductivity tensor and their dependence on the frequency of the external field is studied. Finally, some possible means for an experimental check of the calculations are suggested. (auth)

**18613** (CONF-680113-(Vol.2), pp 671-5) EXPERIMENTAL STUDY OF ION ACCELERATION IN A HF ACCELERATOR WITH A GRADIENT OF THE STEADY MAGNETIC FIELD. COMPARISON WITH THEORETICAL RESULTS. Abgrall, F.; Bardet, R.; Geller, R. (Commissariat a l'Energie Atomique, Saclay (France). Centre d'Etudes Nucleaires). (In French).

The plasma formed by a traveling-wave accelerator of the Circé type is injected into a uhf cavity of a stationary-wave accelerator of the Pléiade type. The experimental results are compared with previously developed theoretical laws. The Circé-Pléiade experimental arrangement, while separating the two functions of ionization and acceleration, permits the behavior of the Pléiade cavity to be studied in the acceleration region, and control of the parameters (injection density, coefficient of voltage rise of the cavity, and hf power) that determine the electron and ion energy of the accelerated plasma. (tr-auth)

**18614** COLLISIONAL-RADIATIVE ELECTRON-ION RECOMBINATION RATE IN RARE-GAS PLASMAS. Chen, C. J. (Jet Propulsion Lab., Pasadena, Calif.). J. Chem. Phys., 50: 1560-66(Feb. 15, 1969).

The minimum de-excitation rate of a recombining electron in the atom is calculated by using Gryzinski's formulation for the electron-atom collision process and Bates and Damgaard's Coulomb approximation for the radiative transition probability. The calculated minimum rate is taken to be the electron-ion collisional-radiative recombination rate. The electron-ion recombination rates are measured in a decaying plasma produced by a transient discharge. The comparison between the theoretical calculations and experimental results for five rare-gas (He, Ne, Ar, Kr, and Xe) plasmas is presented. (auth)

**18615** THE INFLUENCE OF THE ELECTRON DISTRIBUTION FUNCTION ON THE MICROWAVE EMISSION AND HIGH-FREQUENCY CONDUCTIVITY OF A WEAKLY IONIZED DISCHARGE PLASMA. Heymann, Peter (Physikalisch-Technisches Institut, Berlin). Beitr. Plasmaphys., 8: 233-46(1968). (In German).

The influence of the distribution function on the microwave emission and the rf conductivity was investigated. In the positive column of low current discharges through neon and argon the electrons are Druyvesteyn-like distributed, owing to the absence of Coulomb interactions. In this case, the radiation temperature is a function of the dc field in the positive column, of the collision frequency for momentum transfer, and the radiation frequency. With only elastic and excitation terms in the Boltzmann equation the distribution functions were computed. These results are used to calculate the radiation temperature by means of Bekefis formula. Agreement is obtained between the experimental and theoretical results. The rf conductivity does not depend very sensitively on changes in the distribution function; nevertheless the high values of the electron collision frequency obtained from the real part of the rf conductivity could be explained only with a Druyvesteyn-like distribution. (auth)

**18616** EXPERIMENTAL STUDIES OF LINEAR BEAM-PLASMA INSTABILITIES IN A MAGNETIC FIELD. Apel, J. R. (Johns Hopkins Univ., Silver Spring, Md.). Phys. Fluids, 12: 291-302(Feb. 1969).

The interactions of an electron beam with a bounded, uniform, equilibrium plasma have been studied experimentally by varying several of the physical parameters that appear in the dispersion equation. This equation (which takes into account the geometry, the magnetic field, and collisions, but which neglects temperature), is solved for complex wavenumber roots in order to compare the wave variables $\omega$, $k_r$, and $k_i$ with their experimental counterparts. The only instability that has been observed with certainty is a convective one having a frequency f below both $f_{pe}$ and $f_{ce}$, all of which are in the neighborhood of 1 GHz. This frequency, and the associated wavelength and axial growth rate as well, are in reasonable agreement with the calculated values, if the absolute values of the effective plasma frequency as obtained from probe measurements are correct. Data are presented on the behavior of the wave properties with time, distance, beam voltage, frequency, and plasma and cyclotron frequencies; and the existence of several nonlinear effects is noted. (auth)

**18617** PLASMA PHYSICS: MANIFOLD COMBINATIONS. Lehnert, Bo. (Kungliga Tekniska Hogskolan, Stockholm). Tek. Tidskr., 99: 167-72(1969). (In Swedish).

A review is made on plasma physics. Its fundamentals and applications are briefly described. (Swed)

## *Kinetics (Experimental)*

**18618** (AD-671512) THE TRANSVERSE INJECTION OF A DENSE PLASMA INTO A LINEAR OCTUPOLE MAGNETIC FIELD. Technical Report. Boyd, Jim A.; Duesterhoeft, W. C. Jr. (Texas Univ., Austin. Plasma Research Lab.). Apr. 18, 1968. 148p. (TR-46; AFOSR-68-0877). CFSTI.

The paper presents the experimental results on the transverse injection of a dense plasma into a linear octupole magnetic field. Magnetic and electric probes were used to observe the interaction of the streaming plasma with the octupole field. By time- and space-resolving the signals from these probes, information related to the motion and density of the plasma in the octupole, current densities in the plasma and the transfer of the momentum of the plasma to the mechanical structure were determined. (auth) (USGRDR)

**18619** (AD-674120) BASIC PLASMA PROCESSES. Summary Technical Report, July 1, 1967-June 30, 1968. Phelps, A. V.; Chen, C. L. (Westinghouse Research Labs., Pittsburgh, Pa.). 1968. Contract Nonr-4725(00). 43p. (68-9-E-5-GASES-R-1). CFSTI.

Measurements of the magnitude and wavelength dependence of the specular reflection of light in the vicinity of the cesium resonance lines from a cesium/sapphire interface verify the Taylor-Langmuir formula for the vapor pressure of cesium in the temperature range from 500 to 600°K. This result eliminates the Cs density as a source of systematic error in the previous measurements of the self-broadening of the Cs resonance lines at 8521 and 8944 Å. Measurements have been made of the total amount of diffusely scattered resonance radiation for pure Cs and for Cs-nitrogen mixtures at Cs densities between $10^{14}$ and $10^{16}$ $cm^3$. A preliminary analysis of this data shows that the method is capable of yielding quenching cross sections at high alkali vapor densities. Some features of the results, such as the apparent quenching caused by pure Cs, are not yet understood. (auth) (USGRDR)

**18620** (CONF-680113-(Vol.1), pp 145-7) MULTIPACTING DISCHARGE AT ELECTRON CYCLOTRON RESONANCE. Schrader, W. J. (Stichting voor Fundamenteel Onderzoek der Materie, Jutphaas (Netherlands). Instituut voor Plasma-Fysica).

A new kind of multipacting discharge at the electron cyclotron resonance has been investigated. The discharge mechanism and the energy distribution of the electrons escaping from the discharge are described. (auth)

**18621** (CONF-680113-(Vol.1), pp 179-201) RESONANTLY HIGH-FREQUENCY SUSTAINED PLASMAS WITH AND WITHOUT STEADY MAGNETIC FIELDS. Messiaen, A. M.; Vandenplas, P. E. (Ecole Royale Militaire, Brussels (Belgium). Laboratoire de Physique des Plasmas).

Nonlinear phenomena affect the resonance spectrum of a plasma column excited by a shf field. The luminosity gives a satisfactory measurement of perturbed average plasma density. At high incident energy, the energy absorbed at resonance is sufficient to sustain the plasma in a resonance state. The density of a resonantly sustained plasma column is also studied versus axial magnetic field $B_0$. A striking pattern showing the role of the cyclotron harmonics and extinction at the cyclotron frequency is observed and theoretically interpreted. The evolution of the plasma "tongues" versus $B_0$ is suggestive. (auth)

**18622** (CONF-680113-(Vol.1), pp 429-55) SHELL-STRUCTURED ELECTRON-CYCLOTRON PLASMA IN A MIRROR MACHINE. Ikegami, H.; Tanaka, S.; Takayama, K.; Ikezi, H.; Kodama, T.; Hosokawa, M. (Nagoya Univ. (Japan). Inst. of Plasma Physics); Ohnishi, H.; Shiina, S. (Nihon Univ., Tokyo. Dept. of Physics).

An investigation of hot electron plasmas produced in a mirror machine (1200G-4000G-1200G) by microwaves was made. The plasma consists of hot electrons, cold electrons, and cold ions. The hot electrons are observed to be bunched in a shell structure, which is due to the heating mechanism in a mirror machine. Instabilities are triggered artificially during the afterglow of the hot-electron plasma and various properties of the instabilities are investigated. (auth)

**18623** (CONF-680113-(Vol.1), pp 457-83) THE MEASUREMENT OF THE ANISOTROPY OF THE VELOCITY DISTRIBUTION AND THE FREE-FREE BREMSSTRAHLUNG PRODUCED BY ELECTRONS IN AN ELECTRON CYCLOTRON RESONANCE PLASMA. Shobet, J. L. (Wisconsin Univ., Madison).

The anisotropy of the electron velocity distribution in an electron cyclotron resonance plasma in a uniform magnetic field was measured. The method of measurement utilized the plasma diamagnetism and a rf probing mode to obtain the electron temperature perpendicular to the magnetic field lines. Particle end flux was measured by an $\vec{E} \times \vec{B}$ energy analyzer to obtain the parallel temperature. Measurements of two properties of the emitted free-free bremsstrahlung from an electron cyclotron resonance plasma were made. These were the radiation intensity and the spatial distribution of the photons as a function of angle with respect to the magnetic field axis. The intensity was maximum for directions of observation along the field lines. The spectral distribution showed that the average emitted x-ray photon was more energetic along the field lines than across them. A theoretical development that considers quantum-mechanical nonrelativistic transitions, which correspond to the conditions of the experiment, is given. The theory predicts the observed measurements and also, in the limit of low-energy photons, (non-quantum-mechanical transitions) corresponds to previous developments. (auth)

**18624** (CONF-680113-(Vol.2), pp 701-25) INVESTIGATIONS OF THE ACCELERATION OF PLASMA WITH TRAVELING ELECTROMAGNETIC WAVES. Bieger, W.; Gresser, H.; Hoenen, F.; Laeuter, R.; Richter, F.; Stampa, A.; Tuczek, H. (Kernforschungsanlage, Juelich (West Germany). Institut fuer Plasmaphysik).

With regard to the application in plasma wind tunnels or propulsion devices, the electrodeless generation and acceleration of plasma by an electromagnetic wave traveling along a special transmission line are investigated. The first aim was to obtain information on the interaction of the wave with the plasma and to determine the initial parameters for effective operation. In the first experiments the efficiency of the process was not a primary concern. The transmission lines were terminated in matched loads where the whole electromagnetic energy at the output of the circuit, of the order of 100 MW, was dissipated. Such devices can be operated only in a pulsed manner, because it is practically impossible to maintain such high energy for long periods of time. Plasma pulses with a length of about 1 m, densities up to $10^{14}$ cm$^{-3}$ and particle velocities between $5 \times 10^6$ cm/sec and $1,2 \times 10^8$ cm/sec could be produced. The interaction of wave and plasma could be described in good agreement with a simple model in which one assumed the ions of the plasma to be reflected elastically on a magnetic piston. For the production of longer or continuously streaming beams it appears necessary to go over to a feedback circuit, where the energy at the output of the line is reinjected at the input by using an appropriate transformer. A high-frequency oscillator is used to compensate the energy losses resulting from ohmic effects and from the plasma acceleration. The realization of such a circuit was studied theoretically and experimentally. (auth)

**18625** (CONF-680113-(Vol.2), pp 727-41) MEASUREMENT OF THE CONDUCTIVITY AND VELOCITY OF A DENSE PLASMA ACCELERATED BY A MEDIUM-FREQUENCY ELECTROMAGNETIC FIELD. Fournier, Gerard; Rager, Jean-Pierre; Sitt, Bernard (Office National d'Etudes et de Recherches Aerospatiales, Chatillon-sous-Bagneux (France)). (In French).

In an annular induction machine where the current density j is expressed as a function of the electric field E, the magnetic field B, the velocity v, and the discharge by a simple relation: $j = \sigma(E - vB)$ ($\sigma$ being the instantaneous local conductivity) the simultaneous use or nonuse of passive inductive probes permits two characteristic macroscopic magnitudes to be evaluated for the formed plasma: temperature ($2.10^{4}$°K) and velocity v (a few km s$^{-1}$). (J.F.P.)

**18626** (CONF-680113-(Vol.2), pp 743-68) RESONANT INTERACTION OF A HIGH-ENERGY HF FIELD AND A STEADY MAGNETIC FIELD WITH A PLASMA. THE ICARE MACHINE. Briand, P.; Consoli, T.; Grelot, P.; Slama, L.; Vial, P. (Commissariat a l'Energie Atomique, Saclay (France). Centre d'Etudes Nucleaires). (In French).

A description of the Icare machine is given. The operation characteristics, diagnostics used, and the experimental results are discussed. It is concluded that in its actual form the operation of the Icare machine is in satisfactory agreement with theory. Certain limitations are apparent, some resulting from the nature of the injection plasma, others from the geometry and experimental conditions. It can be said, however, that Icare permits a better test of the validity of theoretical conjectures on the operation of mixed-field accelerators in the region of high energies and high densities. (J.F.P.)

**18627** (CONF-680113-(Vol.2), pp 769-74) INTERACTION OF A PROGRESSIVE HIGH-FREQUENCY FIELD IN CONTINUOUS REGIME. Bouchardy, P.; Dupas, L.; Leroy, J. (Commissariat a l'Energie Atomique, Saclay (France). Centre d'Etudes Nucleaires). (In French).

The acceleration of ions by a traveling right circular wave with electron cyclotron resonance is studied in the Circe. The wave is propagated along a static magnetic field. The resonance occurs in a region where the magnetic field is decreasing. Either a mirror configuration or a magnetic field that decreases along the axis of the machine can be used. (J.F.P.)

**18628** (CONF-680113-(Vol.2), pp 775-807) PLASMA ACCELERATION AT HARMONICS OF THE ELECTRON CYCLOTRON FREQUENCY. Okabayashi, M.; Ishizuka, H. (Tokyo Univ. (Japan). Dept. of Physics).

Acceleration of plasma by mixed (static magnetic + hf electromagnetic) fields was studied using 1-MW microwaves and a traveling-wave-type accelerating structure. The maximum ion energy and the acceleration efficiency reached 60 keV and 28% respectively. Ion energy showed peaks at magnetic field strengths giving $\omega_c = \frac{1}{4}\omega, \frac{1}{2}\omega, \omega, \frac{3}{2}\omega$, and $2\omega$ at 2 to 3 cm from the plasma source. High-frequency waves propagated down to the $\omega_c \approx w$ region and completely damped there. The Doppler shift was observed in the $\omega_c > \omega$ region. Higher-order radial mode structure of the hf electric field was found. The mechanism of plasma acceleration at harmonics of the electron cyclotron frequency is discussed in connection with the wave behavior. (auth)

**18629** (UCRL-Trans-10325) CONCERNING THE BEHAVIOR OF CONTINUOUS MERCURY RADIATION AT HIGH DENSITIES. Rompe, R.; Schulz, P.; Thouret, W. Translated for Univ. of California, Lawrence Radiation Lab., Livermore, from Z. Phys., 112: 369-76(1939). 15p. Dep. CFSTI.

The intensity of the continuous high-pressure mercury discharge was measured for a range of densities from 0.5 to $1.5 \times 10^{20}$ atoms cm$^{-3}$ and over a range of current strengths from 4 to 12 A using a Koenig-Martens spectral photometer. An increase in the intensity with current strength at $J^{\frac{1}{2}}$ and an almost proportional increase with density, independent of the position of the spectral region studied, are shown. The results can be explained by a theory due to Unsoeld, according to which the intensity of the continuum should increase independently of the frequency of emission, proportionally to the density, and exponentially with the temperature. At higher densities and current strengths, indications were found for a decrease of the excitation potential $V_k$ of the continuum. (auth)

**18630** NITROGEN PINK AFTERGLOW IN A MAGNETIC FIELD. Anketell, J.; Dugan, C. H. (York Univ., Toronto). J. Chem. Phys., 50: 1893-4(Feb. 15, 1969).

The enhancement of optical emissions from the nitrogen pink afterglow on the application of an axial magnetic field is reported. The transitions $C\ ^3\Pi_u \rightarrow B\ ^3\Pi_g$ (second positive system) of $N_2$, $B\ ^3\Pi_g \rightarrow A\ ^3\Sigma_u^+$ (first positive system) of $N_2$, and, most affected, $B\ ^2\Sigma_u^+ \rightarrow X\ ^2\Sigma_g^+$ (first negative system) of $N_2^+$ were observed. A pronounced enhancement of emission from $N_2$ as well as from $N_2^+$ was found. (TSS)

**18631** CONCERNING THE CHANGE IN ELECTRON ENERGY DISTRIBUTION IN MOVING STRIATIONS? Kagan, Yu. M.; Kolokolov, N. B.; Milenin, V. M. (Leningrad State Univ.). Zh. Tekh. Fiz., 38: 1821-3(Oct. 1968). (In Russian).

Under the conditions of existence in a positive discharge column of moving striations of charged particles the usual methods used for determining electron energy distributions can turn out to be useless. A method is proposed which determines the function of distribution of electrons according to energies for each point on the striation. The distribution function for various points on the moving striation was obtained for mercury–neon and mercury–krypton mixtures. (tr-auth)

**18632** THE PREBREAKDOWN CURRENTS IN HIGH VACUUM. II. NATURE OF EMISSION CENTERS. Juettner, B. (Physikalisch-Technisches Institut, Berlin). Beitr. Plasmaphys., 8: 309-14(1968). (In German).

Pre-breakdown currents of low order of magnitude ($10^{-15}$ to $10^{-11}$ A) were measured with uhv conditions in order to obtain information about the nature of the emitting sites. Heating the cathode to temperatures >600°C or ionic bombardment in a glow discharge reduced strongly the current, but it was considerably increased by oxidation. Exposure to atmospheric air and following bakeout at 400°C had a similar effect as the artificial oxidation. Hence, starting the experiments the first emission may come from nonmetallic structures as oxide needles. It is therefore concluded that special precautions are necessary in order to avoid nonmetallic emission sites of high emissivity even with uhv conditions. (auth)

**18633** LABORATORY STUDY OF TURBULENCE IN COLLISION-FREE SHOCKS. Patrick, R. M.; Pugh, E. R. (Avco Everett Research Lab., Everett, Mass.). Phys. Fluids, 12: 366-78(Feb. 1969).

In an earlier paper the authors describe a plasma wind tunnel that produces a steady collision-free flow. A shock wave standing in front of a magnetic obstacle was produced in this flow. The changes in magnitude and direction of the magnetic field across the shock wave were found to be in agreement with values predicted using the magnetohydrodynamic Rankine–Hugoniot relations. This work has been extended using electric field measurements to determine the overall flow patterns. The electron density has been measured with a laser interferometer, and the density ratio across the shock wave has been found to be consistent with the shock wave equations. The power spectra of the magnetic and electric fluctuations have been measured. These fluctuations are consistent with whistler waves standing in the shock front. The power spectrum shows large variations with position in the shock with the highest frequencies appearing near the toe of the shock wave. The amplitude and frequency variation of the power spectrum is quite similar to space data where the latter is available. The electric field fluctuations are found to be proportional to the magnetic fluctuations with a proportionality constant equal to the flow velocity. The absolute magnitude of the magnetic turbulence is too low to absorb all of the dissipation required for the shock wave and a simple model using wave–particle interactions is suggested. (auth)

**18634** TRANSIENT PLASMA SHEATH: DISCOVERED BY ION-ACOUSTIC WAVES. Alexeff, I. (Oak Ridge National Lab., Tenn.); Jones, W. D.; Lonngren, Karl; Montgomery, David. Phys. Fluids, 12: 345-6(Feb. 1969).

For a high negative voltage $V_0$ placed impulsively at the edge of a plasma, a sheath is formed of thickness $X = (2eV_0)^{\frac{1}{2}}(4\pi n_i e^2)^{-\frac{1}{2}}$. This sheath is observed by extrapolating the position of the leading edge of an ionic sound-wave pulse back to zero time. The ion number density can be obtained from this sheath. (auth)

**18635** STUDY OF MOVING STRIATIONS IN PLASMAS. V. A STUDY OF THE SATURATION PROCESS IN LARGE AMPLITUDE MOVING STRIATIONS. Bolton, R.; Sicha, M.; Drouet, M. G. (Univ. of Montreal). Can. J. Phys., 47: 779-85(Apr. 1, 1969).

Measurements made near the Pupp current limit for the existence of moving striations in neon illustrate the process of saturation of moving striations as the column amplification increases. The measurements show that the nature of the striations changes from the characterization of Pekárek for small amplitude to that of Nedospasov for large amplitude as the plasma potential variation in the striation approaches the potential drop of the external electric field per striation wavelength. Measurements of the relative phases of electron temperature, plasma potential, and luminous intensity for striations near the Pupp current limit are presented. (auth) (Canada)

**18636** ION CYCLOTRON RESONANCE ACCELERATION IN A NONUNIFORMLY MAGNETIZED PLASMA. Miyake, S.; Sato, T.; Takayama, K. (Nagoya Univ., Japan). Phys. Lett., 28A: 613-14(Feb. 10, 1969).

In an axially nonuniform magnetic field it is observed that ions in a plasma are accelerated under the influence of an rf electric field. (auth)

**18637** IMPEDANCE OF AN ANTENNA IN ANISOTROPIC PLASMA. Ito, Hiroshi (Yamanashi Univ., Kofu, Japan); Mushiake, Yasuoto. Electron. Commun. Jap. (Engl. Transl.), 51B: 64-71(Feb. 1968).

The input impedance characteristics of a quarter-wavelength antenna immersed in a plasma-filled space chamber with volume of 2 $m^3$ were measured. Comparison of the experimental results with theoretical values showed satisfactory agreement between them. An expression was obtained for the near field of a dipole immersed in an anisotropic plasma. By using this expression and assuming a suitable current distribution along the antenna (a distribution based on earlier calculation) the input impedance of the half wavelength antenna is obtained. The dependence of the antenna impedance characteristics on various plasma parameters was investigated and a proposal made concerning the use of a probe antenna in plasma diagnostics. The results obtained here may be useful as basic data in designing antennas for use in artificial satellites or designing radio probes for ionospheric sounding. (BBB)

**18638** ELECTRIC PROPERTIES OF XENON PULSE PLASMA. Guenther, K. (Physical-Technical Inst., Berlin). Beitr. Plasmaphys., 8: 383-401(1968). (In German).

A description is given of an experimental arrangement for studying xenon pulse discharges with high-specific-power dissipation. By means of time-resolved measurements of discharge pressure and spatial radiation distribution, the discharge was observed and periods of time are found during which the discharge conditions are quasistationary. Electrical measurements yield the electrode drop voltages and the electric field strength as functions of pressure and current. A method for determining the discharge pressure from measurements of voltage drop across the lamp and current in closed discharge tubes is discussed. A calculation of temperature dependence of radiated power and electrical conductivity results in discharge temperatures of 10,000 to 12,000°K with an error of 10 to 15%. (auth)

**18639** ELECTROMAGNETIC WAVE GENERATING AND TRANSLATING APPARATUS. Naydan, Theodore T.; Tomiyasu, Kiyo. (to General Electric Co.). U. S. Patent 3,432,722. Mar. 11, 1969. Filed Jan. 17, 1966.

An apparatus wherein a beam of density modulated electrons restricted to longitudinal movement traverses a plasma column having longitudinal and radial gradients. An interaction occurs between the beam and plasma in a section in the plasma column having a resonant frequency approximately equal to the driving frequency of the electron beam thereby permitting an electromagnetic wave to radiate out from the plasma. A cathode positioned inside a circular waveguide enclosing the plasma acts as an inner conductor of a coaxial waveguide, while the outer conductor is coupled to the circular waveguide. (Offic. Gaz.)

**18640** BEAM PLASMA HIGH-FREQUENCY WAVE GENERATING SYSTEM. Naydan, Theodore T.; Koenig, Harold R. (to General Electric Co.). U. S. Patent 3,432,721. Mar. 11, 1969. Filed Jan. 17, 1966.

A system is described wherein a beam of density-modulated electrons restricted to longitudinal motions traverses a plasma column having longitudinal and radial gradients. An interaction occurs between the beam and plasma in a section in the plasma column having a resonant frequency approximately equal to the driving frequency of the electron beam, thereby permitting an electromagnetic wave to radiate out from the plasma. (Offic. Gaz.)

## *Kinetics (Theoretical)*

**18641** (AD-672283) RELATIVISTICALLY INTERSTREAMING BOUNDED PLASMA INTERACTIONS. Martin, Gayle P.; Likuski, Robert K. (Texas Univ., Austin. Plasma Research Lab.). May 15, 1968. 142p. (TR-49; AFOSR-68-1083). CFSTI.

The characteristic equation was formulated and some of its solutions are presented in the form of dispersion diagrams for a circular cylindrical waveguide loaded with several concentric regions of plasma interstreaming at relativistic velocities along the guide axis; the axis is aligned with an externally applied "dc" magnetic field. The small-signal approximation was used in the derivation of the characteristic equation, but the quasi-static approximation was not used, and relativistic terms were retained. The plasma components display no thermal effects except through a collision frequency representing collisions in which all of the particle's "ac" momentum is lost. The dispersion diagrams presented, which were obtained through use of a CDC 6600 computer, represent a variety of electron beam interactions with an electron–ion plasma for modes with no angular variation; some stationary plasma data are also presented. The interactions of an electron beam's fast and slow space charge and cyclotron modes with the first and second plasma cyclotron and space charge modes were calculated for a variety of combinations of beam density, radial size, and velocity. (auth) (USGRDR)

**18642** (AD–674057) INTERACTIONS OF AN ELECTRIC ARC PLASMA WITH TRANSVERSE MAGNETIC FIELDS AND GAS GLOWS. Final Scientific Summary Report, June 1, 1964–November 30, 1967. Fucks, Wilhelm; Bartels, Klaus; Fischer, Ernest; Uhlenbusch, Jurgen (Technische Hochschule, Aachen (West Germany). Physikalisches Institut (I)). Apr. 1968. Contract AF61(052)-805. 79p. (HMP–118; ARL–68–0074). CFSTI.

Interactions of wall-stabilized and free-burning arcs with transverse gas flows and magnetic fields perpendicular to the arc axis are studied. The arc plasma is described by the monofluid approximation and the gas flow is assumed to be laminar, i.e., the Reynolds number of the flow is sufficiently small. Temperature distribution and flow in a wall-stabilized cylindrical arc are calculated, a transverse magnetic field giving rise to a double vortex and a displacement of the maximum of the arc temperature. For a free-burning arc, analytical and numerical methods are developed to calculate the flow field for a given reasonable temperature field and the temperature distribution for a given flow field. For a given approximate temperature distribution, the momentum equation is solved including inertial forces, viscous forces, and Lorentz forces. An analytic solution for a channel model is compared with more rigorous numerical calculations. It is shown that strong magnetic fields or inertial forces can cause a backflow in the arc core. From the energy equation the temperature distribution is calculated for a given homogeneous or inhomogeneous flow field. Assuming cylindrical symmetry the solution leads to an eigenvalue problem which determines the electric field strength in the arc depending on the flow parameters. The three-dimensional temperature distribution of an arc in a homogeneous flow is obtained, prescribing suitable boundary conditions on the electrodes. (auth) (USGRDR)

**18643** (CONF-680113–(Vol.1), pp 101-18) CALCULATIONS ON A SELF-COHERENT FIELD IN A HIGH-FREQUENCY PLASMA ACCELERATOR. Brambilla, M. (Commissariat a l'Energie Atomique, Saclay (France). Centre d'Etudes Nucleaires). (In French).

Analytic expressions for the motion of a particle in a mixed structure, given by E. Canobbio, are used to evaluate the transverse current excited in the plasma. Since the current is a function of the hf electric field, the Maxwell equations permit a self-coherent equation to be written for the determination of the field spatial variation. The analytic solution of this equation shows that the absorption of the electromagnetic energy by the electrons accelerated at the gyro-resonance is quasi-total when the density becomes appreciable. This result is in agreement with the result obtained by Budden, Stix, and Kuckes, beginning with the approximate equation of the electric field. (tr-auth)

**18644** (CONF-680113–(Vol.2), pp 541-603) GYRORESONANT ACCELERATION OF CHARGED PARTICLES IN A NONUNIFORM STEADY MAGNETIC FIELD. Canobbio, E. (In French).

Particle motion in inhomogeneous magnetostatic and high-frequency fields at the gyroresonance is studied in the limit of a large number of particle revolutions in the resonance region. The role played by the magnetic mirror, Doppler and relativistic effects, and the radiation pressure on particle acceleration is discussed. The time dependence of the orbital magnetic flux, the velocity along the magnetic lines of force and the width of the resonance region are calculated. An upper limit is found for the energy of the particle, when the effect of the magnetic field of the wave partially compensates for the change in mass with energy. The method generalizes the results established by C. S. Roberts and S. J. Buchsbaum in a special case, to the more complex situation proposed by T. Consoli (1961) for injecting, accelerating and confining a hot plasma in a magnetic trap. A number of numerical examples are presented for various conditions. The space charge field that develops along the magnetic lines of force in a plasma accelerating structure is taken into account in a simple way, by assuming (T. Consoli) that the electron guiding centers move with the velocity of the ions. The energy transfer to the particles at the parametric resonances is also investigated. (auth)

**18645** (CONF-680113–(Vol.2), pp 605-35) ION ACCELERATION BY SPACE-CHARGE FIELDS IN A HIGH-FREQUENCY PLASMA ACCELERATOR. Canobbio, E.; Finzi, U. (In French).

A theoretical method for determining the electrostatic field that appears in the midst of an accelerated plasma in the high-frequency structure and gradient of a magnetostatic field is presented. (J.F.P.)

**18646** (CONF-680113–(Vol.2), pp 637-42) ENERGY BALANCE IN HIGH-FREQUENCY PLASMA ACCELERATORS. Brambilla, M.; Canobbio, E. (In French).

The gyroresonant acceleration of an electron by a right circular polarized wave in a nonuniform magnetic field was studied previously, assuming that the high-frequency field seen by the plasma electrons is known. This field must, in general, be evaluated by a self-coherent calculation which takes into account the presence of the accelerated plasma. A balance of energy can be made very simply in the case of very high densities, when all the energy is absorbed in the interior of this region in such a way that the amplitude of the wave tends toward zero before the phase between the transverse velocity and the electric field becomes unfavorable to acceleration. (J.F.P.)

**18647** (CONF-680113–(Vol.2), pp 643-69) THEORETICAL OPERATING CHARACTERISTICS OF HF ACCELERATORS AT ELECTRON CYCLOTRON RESONANCE AND WITH A GRADIENT OF THE STEADY MAGNETIC FIELD. Abgrall, F.; Bardet, R.; Gormezano, C. (Commissariat a l'Energie Atomique, Saclay (France). Centre d'Etudes Nucleaires). (In French).

The principal theoretical results obtained previously and their sphere of application are recalled. The energy of the accelerated particles is then calculated as a function of the injected plasma flux and the hf power in the case of traveling-wave accelerator (CIRCE) and in that of a stationary-wave accelerator (PLEIADE). (J.F.P.)

**18648** (IAE–1570) RESONANCE PHENOMENA IN PLASMA AND FLUID FLOW. Timofeev, A. V. (Gosudarstvennyi Komitet po Ispol'zovaniyu Atomnoi Energii SSR, Moscow. Institut Atomnoi Energii). 1968. 146p. (In Russian). Dep.

It was found that stability and oscillations of plasma and ordinary fluid flow are determined by the phenomena developing in resonance points in which the phase wave velocity coincides with the rate of flow. It is shown that in a simple plasma with sufficiently high rate of flow, all undamped intrinsic oscillations are absent. A similar assertion can be found in the Rayleigh theorem for plane-parallel incompressible fluid flow. (R.V.J.)

**18649** STUDY OF TRANSPORT PROPERTIES OF PLASMA USING SEMI-CLASSICAL QUANTUM POTENTIAL. Srivastava, M. P.; Devanathan, C. (Indian Inst. of Science, Bangalore, India). Beitr. Plasmaphys., 8: 247-62(1968).

The current evaluation of transport properties suffers from divergence difficulties resulting from the fact that the usual potentials do not adequately represent the collision mechanism in an assembly of interacting particles, the effect of surrounding particles at large and small distances being neglected. The usual way of avoiding this is by cutting off the ranges (both at upper and lower end) and completely disregarding such influences. A more appropriate procedure would be to use modified potentials (based on physical arguments) which atuomatically avoid such divergences. Using the Chapman–Enskog–Hilbert theory, the transport properties are calculated for the semiclassical quantum potential and are compared with those Debye-shielded potential calculations. The discussion is limited to hydrogen plasma. It was found that there is an increase in the transport properties of the plasma in the direction parallel to the original direction of a test particle and a decrease in the perpendicular direction, due to virtual induced quantum polarization. (auth)

**18650** QUALITATIVE STREAMER THEORY. Lozanskii, E. D.; Firsov, O. B. Zh. Eksp. Teor. Fiz., 56: 670-5(Feb. 1969). (In Russian).

A simplified calculation of development of a streamer is proposed, based on the model of a perfectly conducting plasma produced on the boundaries by electrons moving into and from the plasma. The main conclusions are that the streamer propagation velocity is approximately proportional to its length and the streamer thickness is proportional to the square root of the

length, which is in good agreement with experiment. The plasma density and field strength in the streamer E′ are also estimated. It is shown that E′ is far less than the applied field, which confirms the assumption about the perfect conductivity of the plasma. (auth)

**18651** THEORY OF BACKSCATTERING. Hantzsche, E. (Physikalisch-Technisches Institut, Berlin). Beitr. Plasmaphys., 8: 283-97(1968). (In German).

Electrons emitted from a cathode are partially backscattered to the cathode surface by collisions with gas molecules. No equilibrium between electrons, gas, and field is presumed for a theoretical treatment of this process, in contrast to the conception of Thomson; instead, the effect of single collisions is investigated assuming isotropy of scattering. The collision numbers, which may be calculated from successive integral transforms, are shown to form a monotone-decreasing sequence. In the field-free case, the collision numbers and the back diffusion rates for the first collisions may be explicitly stated; the convergence of this method is rather poor, however. A model for back diffusion in an electric field, whereby the effect of primary collisions only is considered, is completely treatable. The results depend on the angular and energy-distribution of the emitted electrons. A comparison with other formulas and with experimental results for backscattering shows a better agreement between the latter and the equations of this article, than in the case of the Thomson–Loeb relation. The consequences on the theory of cathode fall are briefly discussed. (auth)

**18652** CONTRIBUTION TO THE STUDY OF BEAM–PLASMA INSTABILITY. Popovici, C. (Institutul de Fizica, Bucharest). Stud. Cercet. Fiz., 20: 805-46(1968). (In Rumanian).

The plasma–beam instability is due to the complex interaction of electrons and ions with the waves excited within the plasma. The transfer of the energy of the beam particles to the waves results in a slowing down of the beam and the excitation of the waves. The inverse energy transfer creates ultimately a steady-state condition. As a result of perturbations in the electric field, the electrons or ions are reflected by the potential barrier. The criteria involved in the formation of the beam–plasma instability are examined, reviewing specifically the concave cathode effect in a plane-parallel geometry. The instability generated when critical beam current, gas pressure, and field intensity values are reached in a plasma in which two opposite electron beams are present causes a strong jump of the carrier concentration, the visible and ultraviolet radiation, high-frequency oscillations, and coherent energy losses. Experiments carried out in longitudinal and transverse fields with concave or plane cathodes are reviewed, examining in particular the losses of charged particles and photons by lateral diffusion. (Review article, 185 references). (TTT)

**18653** TRANSFORMATION OF THE BOLTZMANN EQUATION FOR THE ELECTRONIC COMPONENT OF A WEAKLY IONIZED GAS IN THE FORM OF AN INTEGRAL EQUATION. APPLICATION TO A HOMOGENEOUS LORENTZ GAS SUBJECTED TO THE ACTION OF AN ALTERNATING ELECTRIC FIELD. Molinet, Frederic (Institut Henri Poincare, Paris). Compt. Rend., Ser. A, B, 267: 1257-9(Dec. 4, 1968). (In French).

A new method of resolution approximating the linearized Boltzmann equation is proposed which is supported by the theory of linearized integral equations. A weakly ionized gas is considered immersed in a constant magnetic field $\vec{B}$ and in an electric field $\vec{E}(\vec{r},t)$ dependent on the position and the time. (TSS)

**18654** NONLINEAR HIGH-FREQUENCY PLASMA CONDUCTIVITY. Salat, A.; Kaw, P. K. (Princeton Univ., N. J.). Phys. Fluids, 12: 342-4(Feb. 1969).

Some numerical results for the high-frequency nonlinear conductivity of a fully ionized plasma are presented. Special attention has been given to the case when the frequency $\omega$ of the applied electromagnetic field is close to the electron plasma frequency $\omega_p$. Apart from its intrinsic theoretical interest, this frequency range is of relevance to the problem of production and heating of plasmas by laser irradiation. (auth)

**18655** DIFFUSION OF PRECURSOR IONS AND ELECTRONS UPSTREAM OF A STRONG SHOCK WAVE PROPAGATING DOWN A SHOCK TUBE. Cohen, Ira M. (Univ. of Pennsylvania, Philadelphia). Phys. Fluids, 12: 361-5(Feb. 1969).

Photoionization upstream of strong shock waves produces ion–electron pairs. These charged particles diffuse to the shock tube where they recombine unless they are first overtaken by the advancing shock. This diffusion problem, governed by the particle flux equations and Poisson's equation for the self-consistent electric field, is considered in the limiting situation when a dimensionless photoionization rate ($\alpha$) and dimensionless shock speed ($v_s$) are large, and the ratio of ion to electron diffusion coefficients ($\delta$) is small. The $\alpha$ and $v_s$ limits separate the region of production by photoionization from regions of charged-particle diffusion. The $\delta$ limit separates regions of electron diffusion from regions of ion diffusion. The subproblems in these regions are formulated and solutions are obtained when the electrostatic potential at the shock surface is small. The electric current density to the shock tube wall is calculated and the result inverted to express the photoionization rate as a function of current density. The centerline potential is also found and inverted to yield another expression for the photoionization rate. (auth)

**18656** MODEL KINETIC EQUATION FOR DENSE GASES AND LIQUIDS. Wisnivesky, D. (City Coll. of New York). Phys. Fluids, 12: 447-54(Feb. 1969).

A kinetic theory approach to collision processes in dense gases and liquids is presented. The nonlinear collision operator is constructed in terms of the first few moments of the distribution function and contains both a reversible and an irreversible part under time inversion. The advantage of this model is that the linearized equations can be solved exactly. The kinetic equation is used to discuss various problems in the long-wavelength regime, and it is shown that it reproduces many of the properties of dense systems. (auth)

**18657** THICKNESS OF A RESISTIVITY-CONTROLLED HYDROMAGNETIC SHOCK WAVE. Jourdan, P. (EURATOM-CEA, Fontenay-aux-Roses, France). Plasma Phys., 11: 57-69 (1969).

The structure of a hydromagnetic shock wave is studied when resistivity is the only source of entropy. The equations used are classical one-fluid equations and the generalized Ohm's law which describes the relative diffusion of matter and magnetic field due to resistivity. (auth) (UK)

**18658** ENERGY FLOW IN THE ZETA DISCHARGE. Rusbridge, M. G. (United Kingdom Atomic Energy Authority, Abingdon, Eng.). Plasma Phys., 11: 35-55(1969).

The Zeta discharge in the low-density regime is characterized by strong turbulence, rapid loss of plasma, a resistance much larger than that predicted from the electron temperature, and a high ion temperature. A model for the energy flow in this regime is proposed, based on the convective transport of the plasma to the walls. This model leads to coupled equations for the ion and electron temperatures and for the turbulent energy. From these equations, and from their integrated forms which govern the energy balance of the discharge as a whole, predictions of the ion and electron temperatures are obtained which are in gross disagreement with observation. It is shown that agreement can be obtained by introducing an additional energy loss process: thermal conduction along the lines of force which are assumed to follow a random path to the wall. Two other possible energy loss mechanisms are considered and shown to be inadequate alone, although some contribution from either in conjunction with thermal conduction cannot be ruled out. (auth) (UK)

**18659** RATES OF TOTAL AND LOCAL RADIATIVE ENERGY LOSSES IN NONEQUILIBRIUM PLASMAS. Hiramoto, Tatsumi (Kernforschungsanlage, Juelich, Ger.). J. Phys. Soc. Jap., 26: 785-801(Mar. 1969).

Radiative losses are calculated for some combinations of an infinite slab, infinite cylindrical, finite cylindrical, or spherical enclosure of plasma and a constant, linear, parabolic, trigonometric, or periodic distribution of Planck's function caused by nonuniformity in electron temperature. The local loss rate on an axis or a center becomes higher as nonuniformity in Planck's function increases. The rate increases with the increasing distance from the axis or the center in the case of constant Planck's function. On the contrary, for symmetric functions with monotonic decrease, it becomes lower with the increasing distance and negative in the region near enclosure surfaces. The results obtained here are available for the estimation of radiative energy loss from nonequilibrium plasmas in magnetohydrodynamic devices. Especially, the result for periodic distribution of Planck's functions is useful for an analysis of plasmas with fluctuations in electron temperature such as ionization instabilities. (auth)

**18660** RESOLUTION OF BBGKY HIERARCHY FOR TRANSPORT COEFFICIENTS. Fujita, Shigeji (State Univ. of New York, Buffalo). J. Phys. Soc. Jap., 26: 505-21(Feb. 1969).

The rigorous evolution equation for the one-body density matrix n(t) describing a quantum system of interacting particles is not closed according to the investigations of Bogolyubov, Born, Green, Kirkwood, Yvon and others (B-B-G-K-Y hierarchy). The analysis of this equation is made in terms of connected diagrams. It is found that in the limits of large volume and time this equation

can be reduced to a generalized Boltzmann equation which is a closed equation with respect to n(t) and which can rigorously describe linear and nonlinear transport coefficients. (auth)

**18661** PERTURBATION-THEORETIC TREATMENT OF THE INHOMOGENEOUS ELECTRON GAS. Dworin, Lowell (Sandia Lab., Albuquerque, N. Mex.). Phys. Rev., 177: 726-32(Jan. 10, 1969).

This is the first in a series of papers in which the thermodynamic properties of an inhomogeneous electron gas are calculated using the standard many-body propagator formalism. The Weinberg quasiparticle approach is used to give an adequate description of the single-particle transition matrix in the presence of a resonance state. When the propagator formalism is then applied, it is found that the contribution from an infinitely sharp resonance state resembles that which one would obtain from the "ideal" Anderson model with the "mixing" term set equal to zero (the correction terms differ from those of the Anderson model). The partition function and magnetic susceptibility of the "ideal" system is computed, using the propagator formalism in an approximation in which only the zero-energy-transfer terms are included; by comparing the answer with the exact answer, one sees that the approximation is exact in this case. (auth)

**18662** STATIONARY SOLUTION OF THE VLASOV EQUATION WITH EXTERNAL ELECTRIC FIELD AND BGK-COLLISION TERMS. Christoph, Gernot (Arbeitsstelle fuer Statistische Physik, Leipzig). Beitr. Plasmaphys., 8: 371-81(1968). (In German).

A perturbation theory is used in a moving frame for the calculation of the stationary solutions of the Vlasov equation with external electrical fields and BGK collision terms. The first-order Fourier components of the internal potential $\Phi_{ml}^{int}$ exp (imkx - ilωt) are calculated (m ≠ 0, all l) for external periodically space- and time-dependent fields. In a special case, they are compared with the results of Moriyama and Sumi. (auth)

**18663** FLUCTUATION SPECTRUM OF ELECTRONS IN A NONEQUILIBRIUM STATIONARY STATE. Schlup, W. A. (IBM-Forschungslaboratorium, Rueschlikon, Switzerland). Phys. Kondens. Mater., 8: 167-93(1968). (In German).

The Boltzmann equation is used to calculate the time correlation function and the fluctuation spectrum for electrons obeying classical statistics. The stationary joint distribution for one electron to be initially in $k_0 = k(0)$ and finally in $k = k(t)$ is given by the product of the conditional probability and the stationary distribution. These quantities can be found from the Boltzmann equation if there exists, for any initial distribution, a unique solution which satisfies the Markov equation and tends to a stationary solution for large times under stationary conditions. It is proved that these conditions hold for linear collision operators and in the relaxation approximation. General operator expressions for the fluctuation spectrum and the differential conductivity in a stationary electric field are given, which can be evaluated within the usual approximation schemes known for the stationary, nonequilibrium solutions of the Boltzmann equation. In equilibrium, they reproduce the classical fluctuation dissipation theorem. In a nonequilibrium state they define a noise temperature depending on the field. In the relaxation approximation, and for polynomial band structure, the exact solution can be found. For parabolic and biparabolic spherical bands the result is discussed explicitly. (tr-auth)

**18664** NON-STATIONARY GENERALIZED OHM'S LAW FOR WEAKLY IONIZED GAS. Khantadze, A. G.; Gogua, R. A. (Inst. of Geophysics, Tbilisi, USSR). Soobshch. Akad. Nauk Gruz. SSR, 52: 623-6(Dec. 1968). (In Russian).

The generalized Ohm's law for steady-state weakly ionized and nonsteady-state fully ionized gases was studied previously. An attempt is made here to expand the generalized Ohm's law expression to treat a nonsteady-state weakly ionized gas in constant crossed electromagnetic fields, assuming that vertical components of the current density, plasma, and wind velocity are negligible compared with the horizontal components. (R.V.J.)

## Production

*Refer also to abstracts 18576 and 18673.*

**18665** (CONF-680113-(Vol.2), pp 525-40) EXPERIMENTS IN PLASMA GENERATION AND ACCELERATION BY HF FIELDS IN PRESENCE OF A STEADY MAGNETIC FIELD. Datlov, J. (Ceskoslovenska Akademie Ved, Prague. Ustav Fyziky Plazmatu).

Two experiments in plasma generation and acceleration by hf fields in the presence of static magnetic fields are briefly described. The experiments were carried out in a cylindrical cavity using 2400-Mc waves. (M.O.W.)

**18666** FREQUENCY-SHIFTING METHOD OF EXCITING A PLASMA IN A RESONANT CAVITY. Halverson, S. L.; Hatch, Albert J. (Argonne National Lab., Ill.). Appl. Phys. Lett., 14: 79-81(Jan. 15, 1969).

A new method of obtaining a high-density plasma ($n \sim n_{c0}$) in a resonant cavity is described. The method is to increase the frequency of the exciting microwave power source by as much as ~10% while keeping the input microwave power constant and maintaining an impedance match between the source and the cavity. Density increases of the order of seven-fold have been obtained in this way. The result is explained mainly on the basis that the power loss in the impedance-matching network decreases as the excitation frequency is increased. (auth)

**18667** BURST BALLS CREATED BY LASERS. Champetier, Jean-Louis; Couairon, Michel; Vendenboomgaerde, Yves (CEA, Villeneuve-Saint-Georges, France). Compt. Rend., Ser. A, B, 267: 1133-6(Nov. 18, 1968). (In French).

A simple model is given for the evolution of a spherical plasma created in a gas by a laser battery during the laser emission. The flow, self-similar with $^3/_5$ index, is formed by a detonation wave, spherically divergent following an adiabatic expansion. (tr-auth)

**18668** DYNAMICS OF LASER-CREATED PLASMA EXPANDING IN A MAGNETIC FIELD. Tuckfield, R. G.; Schwirzke, F. (Gulf General Atomic Inc., San Diego, Calif.). Plasma Phys., 11: 11-18(1969).

Measurements were made on a plasma created in a vacuum magnetic field by the focused beam from a Q-spoiled neodymium laser. The target material was either a 20-μ quartz or pyrex fiber or a paraffin ($C_NH_{2N+2}$) 20-μ-dia. sphere suspended by a 1-μ quartz fiber. The laser power was ~150 MW with 20-nsec pulse width. Plasma parameters were measured by means of diamagnetic loops and probes, Langmuir probes and a biased ion electron collector. High-speed framing photographs showed an initial spherical expansion. In the presence of a magnetic mirror field of 1200 G the expansion was stopped at a radius of ~1.5 cm. In agreement with theoretical predictions a slight "bounce" was observed, after which the emission light configuration became elliptical in shape with a dark nonluminous central region. The diamagnetic probes showed beta greater than 1 at this 1.5 cm radius, and the signals showed a "bounce" for r greater than 1.5 cm. By scanning a photodiode across the laser beam at the exit window of the vacuum system the time dependence of the energy absorbed by the target as a function of radius was determined. (auth) (UK)

**18669** ON SOME FEATURES OF PLASMA OUTFLOW FROM THE DISCHARGE IN THE MAGNETIC FIELD UP TO 100 kOe. Gabovich, M. D.; Starchik, P. D.; Semenyuk, V. F. (Inst. of Physics, Kiev). Ukr. Fiz. Zh., 13: 1977-82(Dec. 1968). (In Russian).

It is shown that the nonmonotonous dependence of the intensity of the outflowing plasma ion component on the magnetic field strength as well as a formation of the tubular plasma flux may occur during plasma outflow from the hot cathode discharge in the uniform magnetic field up to 100 kOe. A strong radial electric field is localized in the discharge zone opposite the outlet. The interpretation of the phenomenon is presented. (auth)

**18670** THE PRODUCTION OF HIGHLY IONIZED, LOW-DENSITY PLASMAS BY MEANS OF STRONG ULTRAVIOLET RADIATION. Pecorella, F.; Vlases, G. C. (Institut fuer Plasmaphysik, Garching, Ger.). Phys. Lett., 28A: 616-17(Feb. 10, 1969).

Strong ultraviolet radiation produced by a fast high-voltage, dynamically filled linear pinch in xenon is used to ionize low-density molecular hydrogen and the noble gases for application to pulsed plasma physics experiments. The degree of ionization which can be achieved at 1-m torr filling pressure ranges from 22% in $H_2$ to 63% in xenon. (auth)

## Stability

**18671** (AD-671901) EXPERIMENTS ON RESISTIVE INSTABILITIES IN A TOROIDAL PLASMA. Research Report. Stuart, Kenneth (Polytechnic Inst. of Brooklyn, Farmingdale, N. Y. Dept. of Electrophysics). Dec. 1967. Contract Nonr-839(38). 151p. (PIBMRI-1379-67). CFSTI.

Visual observations made on a pulsed toroidal plasma indicate that the current-carrying plasma sheet breaks up into filaments parallel to the direction of the current and perpendicular to the direction of the magnetic field. This process involves the an-

nihilation and fusion of initially opposite magnetic flux lines and leads to a final configuration which corresponds to a lower energy state. Such a state, however, would not be accessible in the absence of dissipation since its attainment requires slippage of the plasma across magnetic flux lines. The operating mechanism must then be associated with a resistive instability of the type first predicted by Furth, Kileen, and Rosenbluth and also by Coppi, Greene and Johnson in Physics of Fluids, Volume 6, 1963. Observations of resistive instabilities under laboratory conditions is of particular interest because these modes are held responsible for many astrophysical and geophysical phenomena such as solar flares and auroras as well as anomalous diffusion rates in fusion devices. The experimental setup consists of a plasma-filled ring-shaped container of rectangular cross section, where a discharge is induced by means of an iron-cored transformer. The time development of the current distribution in the plasma is determined with the help of a combination of magnetic probes and an S. T. L. image-converter camera. Optical spectroscopy is used to calculate the temporal variation of electron number density and temperature. (auth) (USGRDR)

**18672** (AD-673188) ELECTROMAGNETIC INSTABILITIES OF PLASMA. Loh, Chyuan-kong. Translated from Wu Li Hsueh Pao, 20: 289-96(1964). 14p. (FTD-HT-66-499). CFSTI.

Using a method similar to Penrose (Phys. Fluids, 3: 258(1960)), an instability criterion for electromagnetic waves in plasmas with anisotropic velocity distribution is obtained by analyzing the geometrical properties of dispersion relation. The effect of temperature nonhomogeneity on instability and that of particle beams are discussed. Finally, a formula for the first-ordered relativistic connection for Wiebel's rate of growth of the electromagnetic waves is given. (auth) (USGRDR)

**18673** (AD-673512) VELOCITY-SPACE INSTABILITIES IN A SIMULATED FUSION PLASMA AND LASER GENERATION OF PLASMA. Final Report. McBee, Warren D.; Morse, David L. (Sperry Rand Research Center, Sudbury, Mass.). June 1968. Contract AF 49(638)-1541. 48p. (SSRC-CR-68-33; AFOSR-68-1756). CFSTI.

The dispersion of electrostatic waves in a cesium plasma produced by thermal ionization and penetrated by a lithium ion beam is investigated. It is shown that if the ion beam has an anisotropic velocity distribution, instabilities can arise which are analogous to "velocity-space" instabilities observed in some controlled thermonuclear fusion plasma experiments. Damping of the instabilities due to electron–neutral collisions and thermal velocities of the electrons and lithium beam ions is considered. For the parameters of the experiment, the predominant damping mechanism is the thermal velocity distribution of the lithium beam ions, and the damping is sufficiently strong to explain the absence of observed spontaneous oscillations. The physical mechanisms involved in the production of plasma by intense light pulses from a Q-switched laser are considered. An estimated time schedule is given for the production, expansion, and loss of such a plasma created in a magnetic containment system. The development and testing of a high peak-power neodymium-glass Q-switched laser is outlined. The design of a nozzle to produce a jet of cesium vapor through the laser focus of sufficiently high density to allow laser induced breakdown is described. (auth)

**18674** (COO-1478-5) MICROINSTABILITIES IN INHOMOGENEOUS PLASMA. Progress Report, May 1, 1968–January 31, 1969. Kammash, Terry (Michigan Univ., Ann Arbor). Contract AT(11-1)-1478. 8p. Dep. CFSTI.

Research work carried out during this period is briefly discussed for the following: (1) shear stabilization of drift cyclotron modes, (2) ion cyclotron instabilities in confined plasma, (3) flute-like instabilities in plasma with a cylindrical relativistic electron beam, (4) convective and absolute ion cyclotron instabilities, and (5) nonlinear studies. A list of papers published in the open literature during the period is included. (M.O.W.)

**18675** (LA-4081) EFFECT OF AN OSCILLATING QUADRUPOLE FIELD ON THE KINK MODES OF A SCREW PINCH. Ribe, F. L. (Los Alamos Scientific Lab., N. Mex.). Jan. 1969. Contract W-7405-eng-36. 7p. Dep. CFSTI.

Dynamic stabilization of the kink modes in a linear z pinch by means of oscillating quadrupole fields has been reported by Orlinskii. The case of the screw pinch (with longitudinal magnetic field, as in a $\theta$ pinch) where the modes are helical is investigated. The quadrupole field (with no twist or rotational transform) couples the left- and right-handed modes, giving two new normal modes, one of which is unstable. The unstable normal mode is not stabilized by the oscillating quadrupole. (auth)

**18676** ION SOUND INSTABILITY IN A COLLISIONLESS SHOCK WAVE. Krall, Nicholas A. (Univ. of Maryland, College Park). Phys. Fluids, 12: 347-55(Feb. 1969).

The nonlinear development of an ion sound instability is calculated for a case in which a diamagnetic current of electrons propagates across a magnetic field, and in which ion gyration in the magnetic field can be neglected. The energy content of the mode is calculated; the parameter range is appropriate to experiments on collisionless low-amplitude magnetic shock waves. (auth)

**18677** STABILITY OF A ROTATING THETA-PINCH PLASMA. Palsedge, John A. (Los Alamos Scientific Lab., N. Mex.). Phys. Fluids, 12: 336-42(Feb. 1969).

The bounce model has been used to calculate the growth rate of the m = 1 mode of a linear $\theta$ pinch having an isotropic Maxwellian ion distribution function rotating with angular velocity $\omega$. For short wavelength, the perturbation rotates with the ions; for longer wavelength it rotates more slowly. The plasma is unstable above a critical wavelength, with growth times $\tau \approx 25$ μsec for typical values of $\omega$. This result falls between the magnetohydrodynamic result of $\tau = \infty$ (stable) and the rigid body limit of $\tau \approx \omega^{-1}$. Consideration of the m = 2 mode is also included. (auth)

**18678** EFFECT OF MAGNETIC CURVATURE ON DENSITY GRADIENT DRIFT INSTABILITIES. Kitao, Kazuo (Niigata Univ., Japan. Nagoya Univ., Japan). J. Phys. Soc. Jap., 26: 802-7(Mar. 1969).

The effect of magnetic curvature on density gradient drift instabilities is examined for a collisionless plasma in which $\beta$ satisfies $m/M < \beta \ll 1$, where $\beta$ = plasma pressure/magnetic pressure, m and M are the electron and ion masses respectively. For simplicity, the effect of magnetic curvature is simulated by an equivalent gravitational field. The present considerations are restricted to the cases where the wavelength of perturbations is much longer than the mean ion Larmor radius and the radius of magnetic curvature is much larger than the characteristic length of the density gradient. It is found that the slow Alfvén mode, which is unstable in a straight and parallel magnetic field, is stabilized by magnetic curvature with a sign favorable to stabilization of the interchange instability while it remains unstable by unfavorable curvature, and that the fast Alfvén mode remains stable independently of the sign of magnetic curvature. (auth)

**18679** ION-CYCLOTRON INSTABILITIES RESULTING FROM A THERMALLY ANISOTROPIC PLASMA. Scharer, J. (Univ. of Wisconsin, Madison). Plasma Phys., 11: 1-1(1969)

Electromagnetic instabilities occurring in a hot-ion, cold-electron plasma are investigated. The instabilities occur in the neighborhood of the ion–cyclotron frequency and result from a left-hand circularly polarized wave propagating parallel to the magnetic field. This mode interacts with the thermally anisotropic ions to produce the instability. Two ion velocity distributions are discussed. The first assumes a monoenergetic distribution transverse to the magnetic field with a Lorentzian velocity shape parallel to it. The second is an anisotropic Maxwellian velocity distribution. Dispersion relations for the two cases are derived and the presence of instabilities is illustrated by several examples. It is found that the instability can be suppressed by lowering the plasma density. Thermal ion velocity spread parallel to the magnetic field is also shown to suppress the instability, and specific criteria are presented. For unstable cases the resulting growth rates are compared with those for the electrostatic modes of Harris. Examples applicable to neutral injection machines are discussed, and it is shown that the electrostatic modes are dominant. (auth) (UK)

**18680** LOSS CONE INSTABILITY IN AN EXTERNAL HIGH-FREQUENCY ELECTRIC FIELD. Kishimoto, Shun'ichi; Akimune, Hideo (Osaka Univ.). Kakuyugo Kenkyu, 22: 200-16(Feb. 1969). (In Japanese).

Loss cone instability in an external high-frequency electric field is investigated theoretically and the dispersion relation is derived by the Aliev and Silin method. It is proved that loss cone instability at the frequency near $n\,\omega_{ci}$ can be stabilized by the external high-frequency electric field, if the frequency of the applied electric field is off-resonant from the ion cyclotron frequency and its harmonics, where n is the harmonic number and $\omega_{ci}$ is the ion cyclotron frequency. A new growing wave near $1\,\omega_\theta + n\,\omega_{ci}$ may exist and can also be stabilized to a certain degree by the stronger electric field. These results are consistent with the experimental results of PHOENIX and HX qualitatively. (NSA of Japan)

**18681** HYSTERESIS IN THE HELICAL INSTABILITY OF THE POSITIVE COLUMN IN A MAGNETIC FIELD. Imazu, Shingo; Yano, Masaaki (Tokyo Inst. of Tech.). Bull. Tokyo Inst. Technol. (Engl. Ed.), No. 88, 23-32(Mar. 1968).

To study the diffusion of electrons and ions in the positive column in a longitudinal magnetic field B, the electric field E along the tube was measured by many investigators. Recently, the interesting features were found in measurements of E in a hot-cathode helium-filled tube. These characteristics show hysteresis effects near the critical magnetic field $B_c$, above which the positive column is unstable. These effects can not be explained by the theory of Kadomstev and Nedospasov. In this paper, it is proposed that these effects can be explained by considering a thickness of the wall sheath. (NSA of Japan)

**18682** OBSERVATION OF PLASMA INSTABILITY IN A STRONG ALTERNATING ELECTRIC FIELD. Grigor'eva, L. I.; Smerdov, B. I.; Stepanov, K. N.; Fetisov, B. A.; Chechkin, V. V. (Inst. of Physics and Tech., Kiev). JETP Lett. (USSR) (Engl. Transl.), 8: 379-82(Dec. 5, 1968).

Translated from Zh. Eksp. Teor. Fiz., Pis'ma Redaktsiyu, 8: 616-19(Dec. 5, 1968).

Preliminary results are presented of experiments aimed at observing and investigating current instability in a hydrogen plasma situated in the electric field of a fast magnetosonic wave of large amplitude (plasma density $n \sim 5 \times 10^{13}$ cm$^{-3}$, intensity 500 Oe of constant electric field $H_0$, amplitude $H_z \sim 300$ to 500 Oe of axial alternating magnetic field produced in the plasma by a surge circuit at frequencies 7 MHz; the electric field intensity on the periphery is ~300 V/cm, corresponding to a maximum electron drift velocity $u_{Emax} \sim 6 \times 10^7$ cm/sec). The electrostatic oscillations in the plasma were registered by three double electric probes at a floating potential. Each probe consisted of two tungsten wires 0.3 mm in diameter and 2 mm long; the distances between the wires were l = 0.75, 1.5, and 4 mm. The electronic circuitry of each probe made it possible to register oscillations of the electric field in the plasma at frequencies 20 to 120 MHz and intensity $E \gtrsim 50$ V/cm. (TSS)

## *Wave Phenomena*

**18683** (CONF-680113-(Vol.1), pp 77-85) PROPAGATION AND ABSORPTION OF LOW-FREQUENCY WAVES IN A CENTRAL CONDUCTING CONFIGURATION. Adam, J.; Alvarez de Toledo, F.; Rebut, P. H.; Torossian, A. (Commissariat a l'Energie Atomique, Fontenay-aux-Roses (France). Centre d'Etudes Nucleaires). (In French).

The conditions for propagation of low-frequency waves in a hard core configuration have been obtained by numerical integration of a wave equation valid for a cold inhomogeneous plasma. The excitation of two modes of oscillation has been observed in the EPPE experiment, for experimental conditions which agree with the results of the computation. The strong damping associated with the ordinary mode can be explained by the presence of resonant layers in the plasma. (auth)

**18684** (CONF-680113-(Vol.1), pp 119-43) RESONANT ABSORPTION OF ELECTROMAGNETIC WAVES IN A NONUNIFORMLY MAGNETIZED PLASMA. Kuckes, A. F. (United Kingdom Atomic Energy Authority, Abingdon (England). Culham Lab.).

The propagation and collisionless absorption of electromagnetic waves propagating in nonuniformly magnetized plasmas with regions of electron or ion cyclotron resonance are computed. Above a critical density, complete wave absorption is found. At high plasma densities particles with high velocity along the field lines are heated preferentially, whereas at lower densities the slow particles gain more energy. Recent experimental results are discussed in relation to these computations. (auth)

**18685** (CONF-680113-(Vol.1), pp 149-60) ELECTRON CYCLOTRON RESONANCE IN A HOMOGENEOUS STATIC MAGNETIC FIELD. Schram, D. C.; Beukema, G. P. (Stichting voor Fundamenteel Onderzoek der Materie, Jutphaas (Netherlands). Instituut voor Plasma-Fysica).

The influence of the variation of the axial velocity component ($\|E_0,k$) and of the relativistic mass change on the attainable energy, on the characteristic time and length, and on the permittivity of the plasma was studied in various field configurations, i.e., homogeneous E field, standing wave, traveling wave. Preliminary experimental results for the permittivity of an electron plasma in both standing and traveling waves are presented. (auth)

**18686** (CONF-680113-(Vol.1), pp 379-90) NONLINEAR DAMPING OF ELECTROMAGNETIC WAVES IN AN INHOMOGENEOUS PLASMA IN THE ION-GYROMAGNETIC-FREQUENCY REGION. Teichmann, J. (Ceskoslovenska Akademie Ved, Prague. Ustav Fyziky Plazmatu). (In French).

The nonlinear damping of circularly polarized electromagnetic waves propagated in the direction of the magnetic field with a frequency $\omega$ near the ion cyclotron resonance $|\omega - \omega_{ci}| \ll \omega_{ci}$ is considered. Attention is given to the phenomena induced by the nonlinear interaction between electromagnetic modes of stationary spectra and drift waves of frequency $\omega \simeq s\omega_{ci}$, $s \neq 0$, $s = 1, 2, 3, \ldots$. (J.F.P.)

**18687** (CONF-680113-(Vol.1), pp 491-7) POWER DISSIPATION OR GENERATION BY DIFFERENT EXCITED MODES IN A PLASMA. Rol'and, P. (Commissariat a l'Energie Atomique, Saclay (France). Centre d'Etudes Nucleaires). (In French).

Some previous kinematic descriptions of excited modes in a plasma are completed by considering the sense of the energy exchanges corresponding to these different excited modes. A study is made of the energy absorbed or generated by the perturbed region. To include the case of growing waves associated with convective instabilities, this problem is treated in the framework of the theory of wave packets. (J.F.P.)

**18688** (CONF-680113-(Vol.1), pp 499-502) NONCOLLISIONAL DAMPING. Lepechinsky, D.; Rolland, P. (Commissariat a l'Energie Atomique, Saclay (France). Centre d'Etudes Nucleaires). (In French).

The model chosen is that of a spherical probe immersed in a plasma of mercury vapor. The hf current and the rectified current present a resonance peak in the vicinity of the plasma frequency. This peak would be infinite in the absence of damping. Reflection of electrons produces a mixture of phases which absorb the energy and reduce the resonance peaks. Calculation and experiment show that this effect considerably reduces the height of the resonance peaks. (J.F.P.)

**18689** (CONF-680113-(Vol.1), pp 503-10) PROPAGATION OF A $TM_{01}$ WAVE IN A CIRCULAR WAVEGUIDE FILLED WITH AN INHOMOGENEOUS MAGNETIZED PLASMA. Hagebeuk, H. J. L.; de Kock, L. C. J. M. (Stichting voor Fundamenteel Onderzoek der Materie, Jutphaas (Netherlands). Instituut voor Plasma-Fysica).

Maxwell's equations are solved for a $TM_{01}$ wave in a circular waveguide filled with plasma with a parabolic density profile in a very strong magnetic field. At zero density the waveguide is assumed to be beyond cutoff. With plasma, the $TM_{01}$ mode starts to propagate at a critical value of the electron density. An experiment is described in which this phenomenon is demonstrated. (auth)

**18690** (CONF-680113-(Vol.2), pp 511-23) THEORETICAL STUDIES ON WAVE-PLASMA INTERACTIONS IN AN INHOMOGENEOUS MAGNETOSTATIC FIELD. Teichmann, J. (Ceskoslovenska Akademie Ved, Prague. Ustav Fyziky Plazmatu).

A general theory of forces excited in a plasma under the action of a high-frequency field and a given magnetic field is described. The improvements brought about in the theory resulting from recent studies founded on the approximation for the drift motion of the particles are studied. (J.F.P.)

**18691** (SU-IPR-264) NONLINEAR INTERACTION BETWEEN EXTRAORDINARY WAVES IN A COLD PLASMA. Harker, K. J.; Crawford, F. W. (Stanford Univ., Calif. Inst. for Plasma Research). Dec. 1968. Contract AT(04-3)-326. 44p. Dep. CFSTI.

An analysis was made of the nonlinear interaction between extraordinary waves propagating perpendicular to the static magnetic field in a cold homogeneous magnetoplasma. It is first shown that the synchronism conditions for wave-wave interactions can be met over wide ranges of parameters. A theory of the interaction based on cold plasma theory is then described which yields a closed-form solution for signal growth by the mechanism of parametric amplification. Numerical solutions are presented for the growth rate and associated frequencies and wave numbers over a range of magnetoplasma parameters. The relevance of these results to laboratory and space plasma experimentation, and to verification of the theory, is discussed. (auth)

**18692** SELF-FOCUSING OF A PLASMA WAVE ALONG A MAGNETIC FIELD. Taniuti, Tosiya; Washimi, Haruichi (Nagoya Univ., Japan). Phys. Rev. Lett., 22: 454-7(Mar. 10, 1969).

It is shown that at frequencies approximately equal to one-half the electron cyclotron frequency, the threshold power for the self-focusing of the whistler mode becomes sufficiently small to be available for laboratory experiments. (auth)

**18693** QUASI-LINEAR THEORY OF ALFVEN WAVES INCREASING IN NONHOMOGENEOUS MEDIA. Grebinskii, A. S. (Leningrad State Univ.). Zh. Tekh. Fiz., 38: 1190-3(July 1968). (In Russian).

The reaction of Alfven's waves, excited in an inhomogeneous medium along the direction of the magnetic field, on the medium and subsequent change in the medium is investigated. It

is shown that the total energy of the flow and the propagating waves is conserved. It results in a nonlinear change in the energy density of the waves. The results are derived by applying quasi-linear methods to the ideal gas with no dissipation. Hall and thermomagnetic currents are neglected. The behavior of waves is described in terms of a parameter which determines whether the wave energy is changed significantly during the propagation through the medium. In the case of weak waves, these are shown to gain energy up to a saturation level. The method also includes the calculation of the quasi-linear corrections. It can be employed in investigations of any unstable waves in MHD media. (ATD)

**18694** FORMULAS GIVING THE COEFFICIENTS OF REFLECTION AND TRANSMISSION OF AN ELECTROMAGNETIC PLANE WAVE THROUGH A PLASMA BEFORE A SLIT AND BEYOND IN A HYPOTHESIS FOR TRAPEZOIDAL ELECTRONIC DENSITY DISTRIBUTION. Marzat, Claude (Faculte des Sciences Bordeaux. CNRS, Talence, France). Compt. Rend., Ser. A, B, 267: 1424-6(Dec. 23, 1968). (In French).

The formulas for coefficients of reflection and transmission of an electromagnetic plane wave through a plasma are derived. It is assumed the experimental conditions of focusing are arranged in order that the electron density gradient only occurs in the direction of the axis of propagation. A trapezoidal distribution is assumed. (tr-auth)

**18695** DECAY OF A LANGMUIR WAVE: INSTABILITY CRITERION AND RATE OF GROWTH. Perulli, Mariano; Laval, Guy; Pellat, Rene (EURATOM–CEA, Fontenay-aux-Roses, France). Compt. Rend., Ser. A, B, 267: 1129-32 (Nov. 18, 1968). (In French).

An experimental study on the decay of a Langmuir wave shows the existence of an instability threshold $|E_1|_\theta$ whose measured value corresponds (to almost 30%) to the theoretical value. The fluctuating density $n_1$, associated with the amplitude $|E_1|_\theta$ of the wave leads to a ratio $n_1/n_0$ ($n_0$ is the mean density) between $10^{-3}$ and $10^{-2}$. The value of this ratio determines, for this mechanism, the passage from the linear domain to the slightly nonlinear domain. The variation of the growth rate as a function of the amplitude of the wave decaying indicates that the waves remain three-by-three strongly correlated the length of the z axis. (tr-auth)

**18696** LOW-FREQUENCY WAVES AND INSTABILITIES ON THE POSITIVE COLUMN IN A MAGNETIC FIELD. I. ANALYSIS AND STUDY OF AXISYMMETRIC MODES. Ewald, H. N.; Crawford, F. W.; Self, S. A. (Stanford Univ., Calif.). Phys. Fluids, 12: 303-15(Feb. 1969).

An analysis is presented for the normal modes of low-frequency wave propagation on the positive column in an axial magnetic field. Dispersion characteristics are obtained from a hydrodynamic treatment by perturbing a steady-state discharge model which includes generation and ion inertia, and is valid for arbitrary pressure. The resulting complex eigenvalue problem is solved numerically by use of a Fourier–Bessel expansion. In general, two types of waves are found for a given frequency: ion-acoustic waves and electron waves. For the regions of parameter space appropriate to laboratory discharges, the ion-acoustic wave branches are predicted to be heavily damped, except at low pressures where the computer solutions are in general agreement with available data. The electron wave branches do not show instability for axisymmetric modes ($m = 0$), but can be unstable for asymmetric modes ($m \neq 0$). Stable modes only are considered and it is shown that some hitherto unexplained damped waves, observed experimentally, are identifiable as symmetric electron-wave modes ($m = 0$). (auth)

**18697** LOW-FREQUENCY WAVES AND INSTABILITIES ON THE POSITIVE COLUMN IN A MAGNETIC FIELD. II. STUDY OF ASYMMETRIC MODES. Self, S. A.; Crawford, F. W.; Ewald, H. N. (Stanford Univ., Calif.). Phys. Fluids, 12: 316-27(Feb. 1969).

An analysis was presented previously (Ewald, Crawford, and Self, Phys. Fluids, 12: 305(1969)) for the normal modes of low-frequency wave propagation on the positive column in an axial magnetic field, and dispersion characteristics were discussed for axisymmetric ($m = 0$) ion–acoustic and electron wave modes. These studies are complemented with an examination of asymmetric modes ($m \neq 0$). First, the stability of a low-pressure positive column without axial drift has been investigated. It is found that with increasing magnetic field, instability first occurs in high-order modes. Next, the theory has been applied to the positive column over a wide pressure range. The computed results are compared with previous approximate analyses of the current-convective instability. Finally, the specific prediction of the theory that asymmetric electron wave modes, rotating in the sense of the electron diamagnetic drift ($m \geq 1$), should grow convectively for sufficiently large magnetic field has been checked experimentally. Measurements on the propagation of the $m = 1$ wave on a low-pressure mercury-vapor positive column are presented which support this prediction. (auth)

**18698** SOME CONSTANTS OF THE MOTION FOR PERTURBATION OF LARGE-AMPLITUDE ELECTROSTATIC WAVES. Nakayama, Toshio; Oberman, Carl (Princeton Univ., N. J.). Phys. Fluids, 12: 328-9(Feb. 1969).

It is shown that there exists a large family of global quadratic constants of motion for perturbations around the steady large-amplitude electrostatic waves of Bernstein, Greene, and Kruskal. (auth)

**18699** NORMAL MODE REPRESENTATION OF THE HIGH-FREQUENCY PROPERTIES OF AN INHOMOGENEOUS PLASMA. Leavens, W. M. (Boeing Scientific Research Labs., Seattle); Love, C. H. Phys. Fluids, 12: 330-5(Feb. 1969).

Analysis of "exact" numerical solutions of the Vlasov equation for longitudinal perturbations of a realistic inhomogeneous plasma shows that the response $E_p(x)e^{i\omega t}$ to an externally supplied driving field $E_d(x)e^{i\omega t}$ is well described by a normal mode representation $E_p(x) = \Sigma_{n=1}^{N} E_n(x)/\omega^2 - \omega_n^2 \int_0^L E_n(x')E_d(x')\,dx'$. The free oscillation frequencies $\omega_n$ and the normal modes $E_n(x)$ are determined from solutions of the Vlasov equation for a $\delta$-function driving field. The normal mode representation is then used to obtain the solution of the Vlasov equation for a uniform driving field, and the results compare well with "exact" solutions. (auth)

**18700** HIGHER-ORDER LANDAU MODES. Derfler, Heinrich; Simonen, Thomas C. (Stanford Univ., Calif.). Phys. Fluids, 12: 269-78(Feb. 1969).

A systematic account of the infinitely many solutions of Landau's dispersion relation verifies that there is always a least-damped wave provided the wavenumber is real and not zero. This no longer holds when the frequency is real; yet, the mode originally considered by Landau predominates in a limited range. Strong "coupling" is found between this wave and higher-order modes at complex frequencies, or when collisions are taken into account. However this coupling does not give rise to resonances other than at the plasma frequency. Short tables of Landau poles and singular points of the dispersion relation conclude this account. (auth)

**18701** KINETIC MODEL OF TONKS–DATTNER RESONANCES IN PLASMA COLUMNS. Baldwin, D. E. (Yale Univ., New Haven). Phys. Fluids, 12: 279-90(Feb. 1969).

The linearized Vlasov equation is used to describe the coupling to plasma waves in bounded plasmas of externally driven quasi-static electric fields of frequency $\omega$, treating as an example a cylindrically symmetric equilibrium. The coupling takes place at the plasma resonance, where $\omega$ equals the local plasma frequency. It is described by an asymptotic theory based upon the small parameter $v_T/\omega L \ll 1$, where $v_T$ is the electron thermal velocity and L the equilibrium scale length. A previously suggested mechanism based on a WKB solution of the Vlasov equation is then developed to provide trapping of the plasma waves between the plasma resonance and the wall sheath, including the effects of Landau damping. The effect of these internal resonances on the external admittance of the plasma is shown, and a numerical example containing typical experimental parameters is given. A comparison is made with previous theories which utilized a fluid model of the plasma. (auth)

**18702** ON THE PROPAGATION OF NONLINEAR ELECTROMAGNETIC WAVES IN AN IONIZED GAS. De Socio, M. Rend. Ist. Lombardo Sci. Lett., A, 100: 491-517(1966). (In Italian).

By the use of the elementary theory relative to the collisions, the propagation of an elementary wave through a plasma was studied. It was shown that, if the medium is homogeneous, the effect relative to the electromagnetic field due to the variation of the density of the electric charger (due to the propagation) is negligible with respect to the inertial Lorentzian effects. (App. Mech. Rev.)

**18703** STOP- AND PASS-BANDS FOR HARMONIC ION CYCLOTRON WAVES. Kristiansen, M. (Texas Technological Coll., Lubbock); Dougal, A. A. Plasma Phys., 11: 19-23(1969).

Harmonic ion cyclotron waves are shown to possess stop- and pass-band characteristics in essential agreement with the quasi-static ion cyclotron mode theory. No clear stop- and pass-band behavior was observed between the first and second harmonic of the ion cyclotron frequency, however. (auth) (UK)

**18704** PLASMA OSCILLATIONS IN A CONSTANT ELECTRIC FIELD. Stenflo, L. (Inst. of Physics, Uppsala). Plasma Phys., 11: 71-2(1969).

The dispersion relation for longitudinal oscillations is de-

rived for a plasma in a uniform applied electric field for the case where the collision integral can be replaced by a Fokker–Planck term with distinct and energy-dependent relaxation times for momentum and energy. (auth) (UK)

**18705** HARMONIC GENERATION INSIDE A PLASMA COLUMN AT RESONANCE. McIntosh, R. E. (Univ. of Massachusetts, Amherst). IEEE (Inst. Elec. Electron. Eng.) Trans. Microwave Theory Tech., MTT-16: 950-1(Nov. 1968).

Harmonic generation inside a plasma column at resonance is considered. Experiments were performed in which harmonics of an S-band signal were observed. The plasma column was formed by creating a low-pressure mercury vapor discharge inside a 0.90-cm-dia pyrex tube. By controlling the discharge current, the average plasma frequency could be adjusted up to 7 GHz. By exciting the plasma with sufficiently large input signals, it was possible to observe the generation of the second and third harmonic signals. Measurements of signals at the second harmonic agreed with earlier measurements in that these signals were large in the Tonks–Dattner resonances ($\omega \cong \omega_p$) of the incident signal. In addition, large second-harmonic signals were measured near $\omega \cong \omega_p/2$, which indicated that the enhancement of harmonic signals occurs at resonances of the harmonically generated signal. It is shown how the third-harmonic power varied with the plasma discharge current. It was apparent that the third-harmonic signal was largest near the Tonks–Dattner resonance ($\omega \cong \omega_p/3$). The third-harmonic power was also observed as a function of input power and the resulting measurements which appear demonstrated that the relation between the third-harmonic power and the incident power was not cubic at either of the resonances as might be expected. It was concluded that the average plasma frequency was not always representative of the plasma frequency in the region of the column where the harmonic generation is taking place. (BBB)

**18706** PARAMETRIC EFFECTS OF AN ALTERNATING FIELD ON INHOMOGENEOUS PLASMAS. Amano, Tsuneo (Osaka Univ.); Okamoto, Masao. J. Phys. Soc. Jap., 26: 529-40(Feb. 1969).

Parametric effects of an alternating electric field on an inhomogeneous plasma in a constant magnetic field are studied by taking into account density gradients. A general dispersion relation governing the four-mode coupling of electrostatic waves is obtained in terms of linear susceptibilities of the plasma. The dispersion relation is applied to the analysis of the parametric excitation of ion–acoustic and Langmuir waves. It is shown that the parametric coupling via density gradient may have important effects in the experimental condition of Stern and Tzoar. It is also shown that if the pumping frequency is about twice the Langmuir (or upper hybrid) frequency, the Langmuir (or upper hybrid) mode can be excited by the inhomogeneity of the plasma. The threshold intensity is sufficiently low to be attainable by microwave irradiations. (auth)

**18707** WAVE TRAINS PROPAGATING AT AN ANGLE TO A MAGNETIC FIELD IN A COLLISIONLESS PLASMA. Inoue, Yoshinori (Osaka Univ.). J. Phys. Soc. Jap., 26: 521-8(Feb. 1969).

Nonlinear periodic waves propagating at an angle to a magnetic field in a collisionless plasma are studied on the basis of the so-called two-fluid plasma equations. The phenomena to be investigated are assumed to have a length scale of the ion Larmor radius, so that the electron mass may be neglected. The analysis is developed first for a cold plasma, then for plasma with the adiabatic exponent $\gamma_i = \gamma_e = 2$. In the former case, the solution is expressed in terms of the elliptic integrals in Weierstrass' normal form. The solitary wave solutions are found for the limiting case that the periodicity is infinite. (auth)

**18708** EFFECTS OF TEMPERATURE RELAXATIONS ON WAVES IN A HOMOGENEOUS PLASMA. Ogasawara, Masatada (Keio Univ., Tokyo). J. Phys. Soc. Jap., 26: 820-6(Mar. 1969).

With use of the Boltzmann equation, dispersion relations are derived for the electron mode by taking account of momentum transfer, electron–ion temperature relaxation, and relaxation of anisotropy in temperature. Ions are regarded to be a heat bath of infinitely large capacity. The dispersion relations are given in the forms of wavenumber expansion. The momentum transfer collision gives damping of waves. The relaxation of anisotropy in temperature also causes damping. The electron–ion temperature relaxation gives additional damping only for longitudinal waves, but not for transverse ones. An explanation of this is given. (auth)

**18709** SUM AND DIFFERENCE FREQUENCY GENERATION IN A PLASMA BY TWO NONUNIFORM ELECTRIC FIELDS IN THE PRESENCE OF A STATIC MAGNETIC FIELD. Ogasawara, Masatada; Mori, Sigehiko (Keio Univ., Tokyo). J. Phys. Soc. Jap., 26: 816-20(Mar. 1969).

Theoretical investigations are made of the effects of a stationary magnetic field on sum-and-difference frequency generation due to two nonuniform rf electric fields applied externally to a plasma. Macroscopic equation of motion without collision term is used as a basic equation. The magnetic field gives rises to sum-and-difference frequency components in electron velocity, even when the two nonuniform rf electric fields are perpendicular to each other. Cyclotron resonance in the electron velocity at sum-and-difference frequency is caused by a perpendicular gradient of the electric fields with respect to the direction of the stationary magnetic field. (auth)

**18710** NONLINEAR KINETICS OF PLASMA. III. FOUR-WAVE INTERACTIONS. Kurasawa, Takasi (Electrotechnical Lab., Tokyo). J. Phys. Soc. Jap., 26: 807-16(Mar. 1969).

Using the Hamiltonian formalism, kinetic equations describing four-wave interactions among the electron waves and among the electron waves and the ion waves are obtained. (auth)

**18711** FLUCTUATIONS IN A PARTIALLY IONIZED PLASMA PLACED IN EXTERNAL ELECTRIC AND MAGNETIC FIELDS. Akhiezer, I. A.; Angeleiko, V. V. (Kharkov State Univ.). Ukr. Fiz. Zh., 13: 2026-35(Dec. 1968). (In Russian).

Collective oscillations and fluctuations are studied in a partially ionized plasma placed in external electric and magnetic fields. It is shown, if the collision rate between charged and neutral particles $\nu$ is small, $\nu \ll \omega$ ($\omega$ is the frequency of fluctuations), the correlation functions possess sharp maxima at the ion–acoustic oscillation frequencies. The level of plasma fluctuations is shown to depend essentially on the values of the external fields. If the value of the electric field is small enough, the level of the fluctuations grows linearly with field increase. When the electric field approaches a certain critical value (depending on the magnitude and direction of the magnetic field), the level of fluctuations grows sharply (critical fluctuations). The characteristics of critical fluctuations depend essentially on the value of the magnetic field. In the case of very strong magnetic fields a sharp growth of intensity occurs for fluctuations with wave vectors k lying in the half-space $kv_0 > 0$. In the case of not-very-strong magnetic fields the intensity of fluctuations grows sharply only for $k||v_0$. The fluctuations in a plasma and plasmous media with a high collision rate ($\nu \gg \omega$) placed in external electric and magnetic fields are also studied. (auth)

**18712** NONLINEAR THEORY OF CYCLOTRON DAMPING OF ELECTROMAGNETIC WAVES IN PLASMA. Shapiro, V. D.; Shevchenko, V. I. (Kharkov State Univ.). Ukr. Fiz. Zh., 13: 1989-94(Dec. 1968). (In Russian).

A nonlinear theory of monochromatic electromagnetic wave damping associated with wave energy transfer to resonance particles is discussed. It is shown that an essential role is played by trapped particles which make oscillating motion in a potential well with a period depending on velocity. A nonlinear decrement is obtained of cyclotron damping of a monochromatic wave. The decrement is an oscillating function of time. (auth)

**18713** RESONANCE TRANSPORT OF ELECTROMAGNETIC WAVES THROUGH OPAQUE BOUNDARIES BY CYCLOTRON PLASMA WAVES. Tsvirko, Yu. A. Ukr. Fiz. Zh., 13: 1572-5(Sept. 1968). (In Russian).

The interaction of cyclotron waves with electromagnetic ones in a moving plasma is studied for the one-dimensional case, assuming that a constant magnetic field $B_0$ is applied along the z axis, the drift is directed against the constant field, and the electromagnetic waves propagate in a direction parallel with the same axis. The equation of motion may be conveniently presented by certain complex circular vector components in the (xy) plane. The interaction was found to possess a resonance character. The boundary conditions, which are isotropic in the (x,y) plane, were further examined. An analysis of the temperature dependence of the scattered light revealed that a decrease of t increases strongly the scattered intensity near the center and decreases at remote locations. An equation was derived to define the correlation between the intensity of scattering as a function of various parameters. (TTT)

**18714** PARAMETRIC EXCITATION OF CYCLOTRON HARMONIC WAVES IN PLASMAS. Tanaka, S.; Sugaya, R.; Mizuno, K. (Kyoto Univ.). Phys. Lett., 28A: 650-1(Feb. 10, 1969).

The parametric excitation of electrostatic cyclotron harmonic waves (Bernstein mode) by means of an electromagnetic wave at the pump frequency twice the excited one are observed experimentally. (auth)

**18715** NONLINEAR DEVIATIONS OF THE DIRECTION OF A REFLECTED WAVE IN VACUUM AT A PLASMA BOUNDARY. Chakraborti, B. (Jadhavpur Univ., Calcutta). JETP Lett. (USSR) (Engl. Transl.), 8: 393-5(Dec. 5, 1968).
Translated from Zh. Eksp. Teor. Fiz., Pis'ma Redaktsiyu, 8: 636-8(Dec. 5, 1968).

A brief theoretical analysis of the reflection of electromagnetic waves at a plasma–vacuum boundary is given. (M.O.W.)

**18716** SCATTERING AND TRANSFORMATION OF THE WAVES IN A PLASMA LOCATED IN EXTERNAL ELECTRIC AND MAGNETIC FIELDS. Angeleiko, V. V.; Akhiezer, I. A. (Kharkov State Univ.). Ukr. Fiz. Zh., 13: 2036-46(Dec. 1968). (In Russian).

Scattering and transformation are studied of electromagnetic waves in a plasma placed in external electric and magnetic fields. It is shown that in the spectrum of scattered (transformed) radiation there appear sharp maxima corresponding to the possibility of propagation of ion–acoustic oscillations (ion-acoustic satellites) in such a plasma. If the values of the external electric field are small enough, the intensity of these satellites grows linearly with field growth. When the electric field approaches a certain critical value, the intensity of the satellites increases sharply, turning (within the framework of the linear theory) into infinity (critical opalescence). The character of the critical opalescence is shown to depend essentially on the value of the external magnetic field. In particular, the scattering cross-section of transversal waves in case of not very strong magnetic field grows sharply for a strictly definite scattering angle. In case of a strong magnetic field a sharp increase of the cross-section must occur for all the waves with $\Theta' > \Theta$ where $\Theta$ ($\Theta'$) is an angle between the wave vector of the incident (scattered) wave and external magnetic field. Scattering of waves by low-frequency oscillations in a weakly ionized plasma placed in external electric and magnetic fields is also considered. (auth)

## Shielding

*Refer to abstracts 17397, 18198, 18265, 18288, 19085, and 19483.*

## Solid-State Physics

*Refer also to abstracts 17759, 17821, 17837, 17841, 17860–17871, 17885, 18419, 19117, 19134, and 19135.*

**18717** (AD–664325) ELECTRICAL MEASUREMENTS AND NUCLEAR ACTIVATION TECHNIQUES FOR RADIATION DAMAGE STUDIES AND IMPURITY ANALYSIS IN SILICON AND IN LASER MATERIALS. Final Report. Peterson, Richard W.; Soper, Ralph B.; Mayburg, Sumner; Kegel, Gunter H. R. (Controls for Radiation, Inc., Cambridge, Mass.). Nov. 9, 1967. Contract AF19(628)-5980. 90p. (AFCRL–67-0596). CFSTI.

The most favorable nuclear method for detecting carbon, nitrogen, and oxygen in silicon at the parts-per-million level (ppM) was determined to be charged-particle activation. Sputtering mass spectrography offers potential for ppM detection as well. Infrared techniques detect only that fraction of the impurity properly located in the lattice to contribute to the infrared vibration, while nuclear techniques and mass spectrography detect all the impurity present. The uniformity of dopants in an Al spectroscopic standard was studied for the dopants Mn, Ga, and Cu by neutron activation. For 100-microgram samples, a standard deviation of 2% was determined for the method. Within this error, Mn and Ga were found to be uniformly distributed while the Cu was not. Recent advances in electroprobe analysis appear to make this method more desirable than nuclear activation, because with nuclear techniques, interfering activities limit the number of impurities that can be determined. Techniques for fabrication of Hall bars for radiation damage studies were developed. A P.M.E. null technique was improved by use of a blue argon laser in order to measure lifetimes below one microsec in silicon Hall samples. A laser test facility was constructed for rare-earth-doped materials. Gamma-ray activation was developed for analyzing for trace amounts of samarium, gadolinium, neodymium, and cerium. (auth) (USGRDR)

**18718** (CEA-R–3604) STUDY OF THE POINT DEFECTS FORMED IN COBALT BY ELECTRON BOMBARDMENT. Sulpice, Gaston (Commissariat a l'Energie Atomique, Grenoble (France). Centre d'Etudes Nucleaires). Dec. 1968. 57p. (In French). Dep.
Thesis.

A study of the point defects formed in cobalt by electron bombardment is presented. The results are compared with those previously obtained for two other ferromagnetic metals of different structure, iron and nickel. A review is given of the literature concerning the creation of point defects, their contribution to resistivity, and their annihilation mode in the three structure types. The experimental techniques adapted, in particular the study of the resistivity increase during a linear temperature rise, are described. The investigations concern the following essential points: the observation of the successive annihilation stages of the point defects formed in pure cobalt, a study of the variations with respect to the doses and energy of the incident particles, and the determination of the annealing kinetics and the corresponding activation energies. The results are finally compared with the various models of point-defect annihilation proposed for other metals: none of these interpretations is in perfect agreement with the results. In the case of cobalt one was thus led to modify the model proposed by the laboratory for iron and nickel. The difference between these three metals is explained by the anisotropic character of the cobalt matrix. (auth)

**18719** (COO–1629-11) THE THERMAL CONDUCTIVITY OF $\gamma$-IRRADIATED KCl CRYSTALS BETWEEN 0.4 AND 4°K. Guenther, Raymond A. (Illinois Inst. of Tech., Chicago). Jan. 1969. Contract AT(11-1)-1629. 113p. Dep. CFSTI.
Thesis.

Thermal conductivity measurements between 0.4 and 4°K were undertaken to test a defect model proposed by Sonder and associates. This model postulates the formation of interstitial chlorine (formed in conjunction with trapped electron centers) and that these interstitials aggregate to form clusters (colloids) —the size of and number of which depend on the irradiation temperature and impurities in the crystal. Using the low-temperature thermal conductivity as a means of detecting and gaging the size of clusters, it was found that for two samples irradiated at room temperature, there were aggregates of an effective radius of 70 Å. A sample irradiated at liquid-nitrogen temperature, and warmed to room temperature before the thermal conductivity was measured, showed no evidence of colloids for the radiation dose available. On the other hand, a sample irradiated at liquid-nitrogen temperature and measured without warming produced results characteristic of colloids, but from the measurements performed, one could not rule out resonant scattering of phonons by point defects. For two samples of different purity, but irradiated identically, the aggregate size appeared to be the same. (auth)

**18720** (IAE–1659) ELECTRICAL CHARACTERISTICS OF STRONGLY-ALLOYED p-n TRANSITIONS FROM ARSENIDE OF GALLIUM (RADIOINDUCED). Domanevskii, D. S.; Litvinov, V. L.; Lomako, V. M.; Tkachev, V. D.; Ukhin, N. A. (Gosudarstvennyi Komitet po Ispol'zovaniyu Atomnoi Energii SSSR, Moscow. Institut Atomnoi Energii). 1968. 47p. (In Russian). Dep.

The mechanism responsible for radioinduced changes in electric properties in p–n transitions of highly alloyed gallium arsenides is described. (tr-auth)

**18721** (INR–934) RADIATION DAMAGE IN P-TYPE GERMANIUM AT LOW TEMPERATURES. Werner, Z. G. (Institute of Nuclear Research, Warsaw (Poland). Reading Univ. (England). J. J. Thomson Physical Lab.); Whitehouse, J. E. (Reading Univ. (England). J. J. Thomson Physical Lab.). 1968. 27p. Dep.

The effect of infrared light illumination and annealing in the temperature range 4 to 120°K on the resistivity of degenerate, gallium- and oxygen-doped p-type germanium irradiated with 2-MeV electrons at liquid-helium temperature was studied. Two types of minority carrier traps were observed. One of them annealed in the temperature range 40 to 80°K while the other was stable up to 120°K. No effect of oxygen doping on the properties of the traps was found. The results of the experiment can be qualitatively understood on the basis of a model assuming that the germanium interstitial atom is mobile at liquid helium temperature and forms complexes with neutral impurity atoms. (auth)

**18722** (JUL–541-FN) SATURATION EVENT OF DEFECT PRODUCTION BY ELECTRON IRRADIATION OF COPPER. Schuster, Hans (Kernforschungsanlage, Juelich (West Germany). Institut fuer Festkoerper- und Neutronenphysik). June 1968. 113p. (In German). Dep.

A study of the behavior of the damage rate, i.e., the increase of the atomic Frenkel pair concentration C per flux density unit, during 3-MeV electron irradiation of a metal as a function of the increasing defect concentration is first theoretically discussed. The experimental study of high-purity copper and irradiated at temperatures below 9°K is then considered. The research installation and the preparation and properties of the samples

are described. The special influence of the experimental technique with high-energy electrons on the measurement results was considered. The damage rate decreased almost linearly in the range $0 \leq C \leq 1.1 \times 10^{-3}$; the concentration $C = 1.1 \times 10^{-3}$ was reduced from the initial value by about 40%. This saturation phenomenon can be traced back to the nonthermal interaction of newly produced defects with the available concentration in Frenkel pairs. A region of 120 to 200 atomic volumes existed around an interstitial atom in which each newly produced vacancy was unstable. The effect of long-range processes have no effect on the saturation phenomenon. The effect of a recombination of neighboring vacancies and interstitial atoms by low-energy interaction with electrons was not completely excluded. A comparison of the results obtained with those obtained in irradiations with heavy particles (deuterons, neutrons, $\alpha$ particles) showed that in the use of high-energy electrons the effect of the dynamic processes on the saturation phenomenon is relatively low. Therefore, the application of the theory of spontaneous recombination is possible without additional assumptions in the case of copper. The study of the saturation phenomenon of defect production with electron irradiation gave a basis for the study of complicated processes which affect the measurement results in the use of other types of irradiation. (tr-auth)

**18723** (KURRI-TR-8) MOESSBAUER EFFECT. Special Research Committee Report, Meeting Dates: December 14, 1964; February 26, 1965. Maeda, Yutaka; Higashimura, Takenobu (comps.) (Kyoto Univ. (Japan). Research Reactor Inst.). [1965]. 107p. (In Japanese and English). Dep.

Separate abstracts were prepared for two sections of the report. (D.C.W.)

*For abstracts of individual sections see: 17821 and 19252.*

**18724** (LA-4055) CLUSTER NUMBER DISTRIBUTIONS ON THE SIMPLE QUADRATIC LATTICE (A MONTE CARLO CALCULATION). Beyer, W. A.; Schrandt, R. G. (Los Alamos Scientific Lab., N. Mex.). Dec. 3, 1968. Contract W-7405-eng-36. 7p. Dep. CFSTI.

Results of a Monte Carlo computation of the distribution of cluster numbers and sizes on a $16 \times 16$ quadratic lattice are presented. (auth)

**18725** (UCRL-18315(Rev.)) DETECTION OF NMR BY NUCLEAR RADIATION. Shirley, D. A. (California Univ., Berkeley. Lawrence Radiation Lab.). July 1968. Contract W-7405-eng-48. 41p. (CONF-680901-2). Dep. CFSTI.

From 15th A.M.P.E.R.E. Colloquium, Grenoble, France.

A description is given of some of the more important features of the various experiments known collectively as NMR/RD (radiative detection of NMR). NMR/RD is contrasted with conventional NMR to emphasize their essential differences. A unified theoretical description of NMR/RD is briefly described. Experimental results are discussed. (M.O.W.)

**18726** SPIN-WAVE INELASTIC SCATTERING ON MAGNETIC METALS. Nathans, R. (Brookhaven National Lab., Upton, N. Y.). Met. Soc. Conf., 43: 143-60(1968).

From Symposium on Neutron Scattering, Los Angeles, Calif. See CONF-670210.

Spin-wave dispersion curves (magnon excitations), as determined by neutron scattering and resonance, are discussed for the ferromagnetic 3d metals and their alloys. Equations are presented, and experimental arrangements and results are discussed. 13 refs. (D.L.C.)

**18727** MAGNETIC STRUCTURES OF RARE EARTH ALLOYS. Koehler, W. C. (Oak Ridge National Lab., Tenn.). Met. Soc. Conf., 48: 99-141(1968).

From Symposium on Neutron Scattering, Los Angeles, Calif. See CONF-670210.

After a review of the magnetic and crystallographic properties of the pure metals, a summary is presented of the magnetic structure properties of the alloys of the rare earth metals with each other and with Sc, Y, and Th. In the concluding discussion, an attempt is made to correlate the results in terms of current theories. 45 refs. (D.L.C.)

**18728** DISTRIBUTION OF MAGNETIC MOMENTS IN FERROMAGNETIC ALLOYS. Cable, J. W. (Oak Ridge National Lab., Tenn.). Met. Soc. Conf., 43: 31-57(1968).

From Symposium on Neutron Scattering, Los Angeles, Calif. See CONF-670210.

A review is presented of neutron scattering studies of the distribution of magnetic moments among the constituent atoms in ferromagnetic binary alloys of the substitutional solid solution type. Alloys based on Ni, Pd, Pt, and Fe are covered. The effects of band structure are considered in a detailed discussion. 54 refs. (D.L.C.)

**18729** RADIATION DAMAGE: SOME NEW TRENDS. Patankar, A. V. (Tata Inst. of Fundamental Research, Bombay). Proc. Nucl. Phys. Solid State Phys. Symp., 1968, Madras, 130-43(1968).

From Nuclear Physics and Solid State Physics Symposium, Madras, India. See CONF-680212.

The major part of investigations of radiation damage in solids has been confined to structure-sensitive properties, since the damage is essentially caused in the crystalline lattice. This paper is devoted to a discussion of color centers, a class of radiation damage in ionic solids, mainly because their most attractive feature is the utilization of a variety of techniques and their combinations to extract information of great importance. Specifically, studies on F centers, aggregate centers, M centers, and R and N centers are reviewed. 45 references. (L.M.T.)

**18730** INTERPOLATION METHOD FOR THE MANY-BODY PROBLEM. Kijewski, L.; Percus, J. K. (New York Univ., N. Y.). Contracts AF-AFOSR-945-65; AT(30-1)-1480. J. Math. Phys. (N. Y.), 8: 2184-93(Nov. 1967). (NYO-1480-95).

Variational principles for lower bounds to the energy, or free energy for $T > 0°$, of many-body systems are obtained in a form requiring density matrix minimization subject to certain model restrictions. The latter restrict the domain in which the density matrices can vary, and only utilize the energy — or free energy — for the model Hamiltonian $H_M$. Increasingly accurate bounds are obtained as the model system begins to resemble the system of interest, and the behavior of the error as $H - H_M$ approaches zero is shown by two examples based upon the Ising model. Coupling the lower bound principle for the free energy with the standard Gibbs–Bogolyubov upper bound principle results in bounds on generalized susceptibility as well. (auth)

**18731** FACTORS INFLUENCING THE STABILITY OF RADIATION DEFECTS IN SEMICONDUCTORS. Crawford, J. H. Jr. (Univ. of North Carolina, Chapel Hill). Contract AT(40-1)-3677. IEEE (Inst. Elec. Electron. Eng.), Trans. Nucl. Sci., NS-15: No. 6, 22-9(Dec. 1968).

From Annual Conference on Nuclear and Space Radiation Effects, Missoula, Mont. See CONF-680706.

Recent advances in the understanding of radiation damage in semiconductors are discussed and areas of difficulty are indicated. Most attention is focused upon (a) stability of close-pair defects resulting from low temperature irradiation with energetic (0.7 to 5 MeV) electrons, (b) the yield of permanent damage in germanium as a function of temperature, (c) damage of intermediate stability in germanium (annealed at 150°K) which is attributable to non-reorientable divacancies, (d) interstitials in electron bombarded germanium, and (e) low temperature damage in electron bombarded p-type germanium and its transformation by light and heating. The inadequacies of certain of the models are discussed particularly in the case of (e). (auth)

**18732** ELECTRICAL PROPERTIES OF NEUTRON-IRRADIATED SILICON AT 76°K: HALL EFFECT AND ELECTRICAL CONDUCTIVITY. Stein, Herman J. (Sandia Labs., Albuquerque, N. Mex.). IEEE (Inst. Elec. Electron. Eng.), Trans. Nucl. Sci., NS-15: No. 6, 69-76(Dec. 1968).

From Annual Conference on Nuclear and Space Radiation Effects, Missoula, Mont. See CONF-680706.

Defects produced in p-type silicon by neutron irradiation were investigated using electrical conductivity and Hall effect measurements at 76°K. Samples from crucible-grown (1, 10, and 50 ohm-cm) and float-zone (10 ohm-cm) boron-doped silicon were irradiated at 76°K with nearly fission spectrum neutrons and annealed isochronally between 76° and 700°K. The electrical properties of neutron-irradiated p-type silicon exhibit an illumination dependence similar to that observed previously in n-type silicon and attributed to the presence of defect clusters. Therefore, neutron-produced changes in the electrical properties of p-type silicon also are attributed to defect clusters. The sensitivity to illumination was observed for all resistivities and for both crucible and float-zone p-type silicon. The illumination-induced conductivity decays slowly with time at 76°K and influences the thermally produced changes in the electrical properties upon annealing for temperatures up to 150°K. Neutron-produced changes in the electrical properties measured after annealing to 150°K are found to be qualitatively consistent with an insulating void model for cluster-space-charge regions. (auth)

**18733** ANNEALING OF 10 MeV ELECTRON DAMAGE IN SILICON. Bass, R. F.; Curtis, O. L. Jr. (Northrop Corporate Labs., Hawthorne, Calif.). IEEE (Inst. Elec. Electron. Eng.), Trans. Nucl. Sci., NS-15: No. 6, 47-54(Dec. 1968).

From Annual Conference on Nuclear and Space Radiation Effects, Missoula, Mont. See CONF-680706.

Annealing studies to investigate the recovery of both the carrier concentration and lifetime in silicon following room temperature irradiation with 10-MeV electrons are described. Both n- and p-type material containing the more common dopants and varying amounts of oxygen were employed to evaluate the effect of these impurities on the annealing behavior. (auth)

**18734** CARRIER SCATTERING FROM DEFECTS IN NEUTRON-BOMBARDED SEMICONDUCTORS. Flanagan, T. M. (Gulf General Atomic Inc., San Diego, Calif.). IEEE (Inst. Elec. Electron. Eng.), Trans. Nucl. Sci., NS-15: No. 6, 42-6(Dec. 1968).

From Annual Conference on Nuclear and Space Radiation Effects, Missoula, Mont. See CONF-680706.

Recent experimental evidence for the clustering of defects in neutron-irradiated semiconductors has led to a revived interest in the model proposed by Gossick. Some theoretical extensions of Gossick's model, in which a simple defect model is used to describe some structure-sensitive properties are presented. Poisson's equation and equations for carrier density are solved for the model in the depletion approximation. The carrier-scattering mobility is calculated from the Born approximation for scattering and the potential derived from Poisson's equation, and the results of the calculation are compared with some experiments. (auth)

**18735** RECOMBINATION CENTERS IN GAMMA-IRRADIATED ARSENIC-DOPED GERMANIUM. Germano, C. A.; Curtis, O. L. Jr. (Northrop Corporate Labs., Hawthorne, Calif.). IEEE (Inst. Elec. Electron. Eng.), Trans. Nucl. Sci., NS-15: No. 6, 34-41(Dec. 1968).

From Annual Conference on Nuclear and Space Radiation Effects, Missoula, Mont. See CONF-680706.

A comprehensive investigation of the properties of recombination centers introduced in As-doped Ge by $^{60}$Co gamma rays is described. Materials of three resistivities were used: ~0.2, ~1 and ~8 Ω–cm. Measurements of lifetime versus temperature were made at low excess densities following various anneals. Numerous measurements of lifetime as a function of excess density with temperature as a parameter and with different annealing histories were performed. Ths position of the recombination center was observed to shift slightly with anneal temperature from E + 0.346 ± .005 eV for room temperature stable defects to 0.322 ± 0.003 eV for samples which have been annealed in the range of ~70°C to ~120°C. These values are based on excess density measurements and assume unity statistical weight. The possible error from this assumption is estimated to be ±0.02 eV. The variation of electron capture probability with temperature was indicated by comparison with temperature dependence data; it varies approximately as $T^{4}$. The hole-to-electron capture probability ratio near room temperature is 400 ± 30%. The arsenic atom appears to play no significant role in the process of recombination center creation or annihilation. (auth)

**18736** A STUDY OF RADIATION EFFECTS ON $SiO_2$ AND $Al_2O_3$ LAYERS USING THERMOLUMINESCENCE GLOW CURVE TECHNIQUES. Mitchell, J. P. (Bell Telephone Labs., Inc., Whippany, N. J.). Contract AF19(628)-67-C-0147. IEEE (Inst. Elec. Electron. Eng.), Trans. Nucl. Sci., NS-15: No. 6, 154-67 (Dec. 1968).

From Annual Conference on Nuclear and Space Radiation Effects, Missoula, Mont. See CONF-680706.

Trap levels in thin layers (500 to 6000 Å) of $Al_2O_3$ and various types of $SiO_2$, all on Si substrates, were investigated using thermoluminescence glow curves in a temperature range from 30 to 300°C. Layers were studied which had been exposed to doses of $^{60}$Co γ radiation up to several Mrads. Previously unirradiated $SiO_2$ layers showed a small density of thermoluminescence traps ($\gtrsim 10^{14}$ cm$^{-3}$). $^{60}$Co γ radiation was found to increase the trap density by an order of magnitude, introducing five peaks in the glow curve. The glow curves were resolved into their component peaks revealing five trap levels with depths ~1 eV. $Al_2O_3$ layers were found to have a larger inherent density of traps than $SiO_2$ layers, also with five levels having depths ~1 eV. $^{60}$Co γ radiation in doses up to ~10 Mrads did not appreciably increase the density of traps. For both the $SiO_2$ and $Al_2O_3$ layers, high-temperature baking increased the thermoluminescence output considerably and caused the five discrete levels to be replaced by a continuum. For the $SiO_2$ layers, it was found that a proportionately larger part of the thermoluminescence output came from the region of the oxide layer close to the $SiO_2$Si interface. For the $Al_2O_3$ layers, the luminescence was more uniformly produced throughout the layer. (auth)

**18737** THE OPTICAL AND ESR SPECTRUM OF Yb(IV) IN THE CUBIC CRYSTAL FIELD. Low, W. (Hebrew Univ., Jerusalem). pp 167-73 of Spectroscopic and Group Theoretical Methods in Physics. Block, F. (ed.). New York, John Wiley and Sons, Inc., 1968.

Paramagnetic resonance spectra were calculated using wave functions deduced from the optical spectrum and compared with the measured g factor for single crystals of $CaF_2$ containing 0.1 to 0.005% $Yb^{3+}$. Experimental and theoretical values of the hyperfine structure were then compared. Hyperfine values were 1 to 2% higher in the crystal than in free atoms, indicating that deviations between theory and experiment can be correlated to "solid-state" effects such as covalent bonding, and possibly to interactions with localized or continuous vibration spectra. (L.M.T.)

**18738** MODULATION OF A MONOENERGETIC NEUTRON BEAM DIFFRACTED BY A VIBRATING QUARTZ SINGLE CRYSTAL. Michalec, R. (Nuclear Research Inst., Rez, Czech.); Chalupa, B.; Petrzilka, V.; Galociova, D.; Zelenka, J.; Tichy, J. Phys. Status Solidi, 31: K95-7(Feb. 1, 1969).

A collimated beam of 1.54-Å neutrons was diffracted on the (200) lattice plane of two quartz rods vibrating longitudinally at 30,385 and 39,105 Hz, respectively. The diffracted beam was analyzed and found to have a time modulation with a basic frequency two times higher than the resonance frequency of the rods, confirming theory. The values of odd-intensity minima differ from these of even ones; this can be explained by the Doppler effect. (D.L.C.)

**18739** X-RAY SURFACE PHOTOCONDUCTIVITY IN n- AND p-TYPE InSb. Kreutz, E. W.; Pagnia, H.; Waidelich, W. (Technische Hochschule, Darmstadt, Ger.). Phys. Status Solidi, 31: K147-50(Feb. 1, 1969).

X irradiation at 79°K increases the electric conductivity of both p- and n-type InSb crystals. The ac field effect in n-type crystals show that x irradiation increases the negative surface charge. The effects of different surface conditions on the conductivity changes were also investigated. Irradiation with light instead of x rays was studied and found to be explainable in terms of surface phenomena. (D.L.C.)

**18740** ESR STUDIES OF V CENTERS IN NaCl($Ca^{++}$) CRYSTALS. Watterich, A. (Research Lab. on Crystal Physics, Budapest); Gecs, M.; Voszka, R. Phys. Status Solidi, 31: 571-7(Feb. 1, 1969).

In OH-free grown NaCl($Ca^{2+}$) crystals, three paramagnetic V centers can be observed under different conditions. Irradiation of the crystals with x rays at liquid nitrogen temperature produces $V_K$ centers; irradiation at dry ice temperature or warming up the $V_K$ center causes the $V_K^M$ center to appear. At room temperature, x irradiation leads to a paramagnetic center that may be considered with high probability to be a $V_F$ center. (auth)

**18741** LINE INTENSITIES IN PROTON SCATTERING PATTERNS. Barrett, C. S. (Univ. of Chicago). Trans. Met. Soc. AIME, 245: 429-30(Feb. 1969).

A simple method is given that will give a rough approximation of the relative intensities of the lines in films of the proton backscattering patterns of a given crystal. This method is found to be useful in practice, although it is not a valid computation of intensities or of film darkening by either dynamic or kinematic diffraction principles or by trajectory calculations. Observed and calculated relative line intensities are presented for cobalt, magnesium, CdS, and CdSe. The results indicate that crystals having the same Bravais lattice and axial ratios but different atomic distributions can yield distinguishable patterns, and that the sequential ordering of the lines from strongest to weakest and the approximate relative intensities can be predicted for nearly all lines for the tests made thus far by this method. (M.H.R.)

**18742** PROTON BLOCKING PATTERNS FOR HCP AND WURTZITE STRUCTURES. Barrett, C. S. (Univ. of Chicago); Mueller, R. M.; White, W. Trans. Met. Soc. AIME, 245: 427-9 (Feb. 1969).

Film-recorded low-energy (~100 keV) proton blocking patterns for hcp and wurtzite crystals are presented. In particular, the sequence of relative line intensities (corresponding to planar blocking) of common hcp metals is compared with those of the wurtzite semiconductors CdS and CdSe. The results show that the sequence is characteristic of structure. For closely similar structures such as those of CdS and CdSe, differences of line intensity attributable to the difference in atomic number, Z, of the scattering centers may also be seen. Blocking patterns are included for cobalt and Cu–Ge alloys. (M.H.R.)

**18743** OBSERVATION OF LOCALIZED RADIATION DAMAGE IN SILICON. Sigmon, T. W.; Gibbons, J. F.; Norris, C. B. Jr. (Stanford Univ., Calif.). Appl. Phys. Lett., 14: 90-2(Feb. 1, 1969).

Protons at 2.8 MeV were implanted into single-crystal ⟨111⟩-oriented silicon at room temperature. Measurements of the damage created as a function of proton fluence show a linear dependence for fluences from $8.2 \times 10^{11}$ to $4 \times 10^{13}$ protons/cm². The resulting lattice defects are found to be positively charged in the presence of a high electric field. The defect introduction rate is found to be $9.1 \times 10^{-3}$ net (+) defects/2.8-MeV proton. Carrier-trapping effects of the damage in low to medium electric fields are negligible to within the sensitivity of the experiment. The technique for making the above measurements is explained in detail. (auth)

**18744** DETERMINATION OF SURFACE CONTAMINATION ON SILICON BY LARGE ANGLE ION SCATTERING. Thompson, D. A. (Canadian Westinghouse Co. Ltd., Hamilton, Ont.); Barber, H. D.; Mackintosh, W. D. Appl. Phys. Lett., 14: 102-3 (Feb. 1, 1969).

Experiments are described in which the energy spectra of 1-MeV $He^+$ ions backscattered 150° from a silicon surface was used to identify and measure the contamination on the surface. Contamination from hydrofluoric acid solutions containing gold and copper in concentrations ranging from 0.1 to 100 parts per million was studied. Less than one half a monolayer of contaminant was easily resolved and identified. Coverages of this order were obtained from solutions containing 0.1 ppm of the contaminant. (auth)

**18745** NUMBER OF ATOMS DISPLACED BY IMPLANTED IONS OR ENERGETIC RECOIL ATOMS. Sigmund, P. (Argonne National Lab., Ill.). Appl. Phys. Lett., 14: 114-17(Feb. 1, 1969).

The validity of the Kinchin–Pease formula is re-examined on the basis of recent progress in the theory of collision cascades and irradiation experiments on semiconductors and metals. (auth)

**18746** QUASI-LINEAR THEORY OF CHARGED PARTICLE INTERACTIONS WITH SPIN WAVES. Makhmudov, Z. Z. Izv. Akad. Nauk Azerb. SSR, Ser. Fiz.-Tekh. Mat. Nauk, No. 5, 64-70 (1968). (In Russian).

Amplification of spin waves in a single-axis ferromagnet by a low-density beam of charged particles, when the initial spectral density of spin waves differs from zero, in a large interval of wave vectors $\vec{k}$ was studied. It was assumed that the initial thermal beam rate $v_t^0$ satisfied the condition $kv_t^0 \ll \gamma_k$ (where $\gamma_k$ is the increment of the spin-wave buildup). (R.V.J.)

**18747** APPLICATION OF THE LINVILL MODEL TO THE DESCRIPTION OF IRRADIATED SEMICONDUCTORS. Durbin, F. Onde Elec., 49: No. 502, 56-62(Jan. 1969). (In French).

The Linvill model, which makes it possible to describe electronic components on the basis of physical data such as doping density, service life of minority carriers, geometry, etc., is discussed. An example taken from the literature is examined. It is envisaged that this work will lead mainly to a study of the transitory photocurrents created by the impulses from ionizing radiation. (auth)

## Theoretical Physics

*Refer also to abstracts 18314, 18389, 18410, 18822, 18831, 18905, 18934, 18988, 19097, 19119, 19122, 19138, 19359, and 19364.*

**18748** (AD-672821) PAULI ALGEBRA AND THE RESTRICTED LORENTZ GROUP. Final Report, September 1965–June 1968. Tisza, Laszlo; Whitney, Cynthia K. (Massachusetts Inst. of Tech., Cambridge. Dept. of Physics). July 1968. Contract Nonr-3963(24). 67p. CFSTI.

Thesis.

The structure of the Pauli algebra of $2 \times 2$ matrices was studied by a combination of standard algebraic techniques with those of complex quaternions. The presentation is self-contained and results in a calculus that is a connecting link between elementary vector calculus and spinor calculus. The formalism is applied to the parametrization of a homogeneous restricted Lorentz group. The structure of this group becomes more transparent in this treatment than in the usual tensoral method. (auth) (USGRDR)

**18749** (AD-672846) MANY BODY THEORY AND QUANTUM FLUIDS. Final Report, November 1, 1965-October 31, 1967. Gross, Eugene P. (Brandeis Univ., Waltham, Mass. Dept. of Physics). June 1968. 4p. (AFOSR-68-1039). CFSTI.

Research was carried out in a program of calculating the properties of a system of interacting bosons from first principles, i.e., from a microscopic point of view. A study was made of the general problem of systematic, nonperturbative approximation schemes in quantum mechanics with special application to electron–lattice problems and many-body theory. (auth) (USGRDR)

**18750** (CEA-R-3608) ANGULAR ANALYSES IN RELATIVISTIC QUANTUM MECHANICS. Moussa, Pierre (Commissariat a l'Energie Atomique, Saclay (France). Centre d'Etudes Nucleaires). 1968. 182p. (In French). Dep.

Thesis. Submitted to Univ., Paris.

An angular analysis of reactions between particles with spin in a fully relativistic fashion was made. One-particle states are introduced, following Wigner's method, as representations of the inhomogeneous Lorentz group. In order to perform the angular analyses, the reduction of the product of two representations of the inhomogeneous Lorentz group is studied. Clebsch–Gordan coefficients are computed for the following couplings: l-s coupling, helicity coupling, multipolar coupling, and symmetric coupling for more than two particles. Massless and massive particles are handled simultaneously. Along the way spinorial amplitudes and free fields are constructed; convergence theorems for angular expansions from analyticity hypotheses are established. Finally, these hypotheses are substituted for the idea of "potential radius" which gives, at low energy, the usual "centrifugal barrier" factors. The presence of such factors had never been deduced from hypotheses compatible with relativistic invariance. (auth)

**18751** (ITF-68-67) CORRELATION AND GREEN'S FUNCTIONS FOR SYSTEMS WITH FOUR FERMION POSITIVE INTERACTION. Bogolyubov, N. N. Jr. (Akademiya Nauk Ukrainskoi SSR, Kiev. Institut Teoreticheskoi Fiziki). 1968. 23p. (CONF-680453-15). Dep.

A method of constructing an asymptotically exact solution for the model of a system with positive pair four–fermion interaction is presented. The problem of constructing asymptotically exact expressions (as $V \to \infty$) for the correlation and Green's functions of any order is investigated. (auth)

**18752** (JINR-P2-4107) RELATIVISTIC QUASIPOTENTIAL EQUATION WITH LOCAL INTERACTION. Mateev, M. D.; Mir-Kasimov, R. M.; Friman, M. (Joint Inst. for Nuclear Research, Dubna (USSR). Lab. of Theoretical Physics). 1968. 31p. (In Russian). Dep.

A relativistic equation of the quasi-potential type with local interaction was studied. Using the method of variation of constants, the integral equations were built for the wave functions of the continuous spectrum and the Jost functions were introduced. The analytic properties of the scattering matrix were considered for exactly solvable cases of the square-well and Coulomb potentials. (auth)

**18753** (UCRL-Trans-10311) COMPTON EFFECT FOR BOUND ELECTRONS. Franz, W. Translated by L. B. Kapp for Univ. of California, Lawrence Radiation Lab., Livermore, from Z. Phys., 90: 623-49(1934). 49p. Dep. CFSTI.

To calculate the Compton effect for an atom, the atom is replaced by a packet of free electrons with the same momentum distribution. In the first part of the work an attempt is made to show that this process represents a plausible approximation, or at least a better one than an approximation used by Casimir. In the second part of the work the scattering formula is derived and compared with the Casimir formula. (tr-auth)

**18754** PROCEEDINGS OF THE INTERNATIONAL SYMPOSIUM ON ATOMIC, MOLECULAR, AND SOLID-STATE THEORY AND QUANTUM BIOLOGY, HELD AT SANIBEL ISLAND, FLORIDA, JANUARY 15–20, 1968. Loewdin, Per-Olov (ed.). Int. J. Quant. Chem., Symp. No. 2, 1-381(1968). (CONF-680116).

Separate abstracts were prepared for eight of the papers. (W.D.M.)

*For abstracts of individual papers see: 18389, 18531, 18532, 18755–18759.*

**18755** CALCULATION OF UPPER AND LOWER BOUNDS FOR EIGENVALUES BY A BOUNDARY CONDITION METHOD: THE QUARTIC OSCILLATOR, HYDROGEN MOLECULE ION, AND HELIUM ATOM. Rosenthal, C. M.; Wilson, E. Bright Jr. (Harvard Univ., Cambridge, Mass.). Int. J. Quant. Chem., Symp. No. 2, 175-85(1968).

From Symposium on Atomic, Molecular, and Solid-State Theory and Quantum Biology, Sanibel Island, Florida. See CONF-680116.

A method for computing upper and lower bounds for bound-state eigenvalues is described. It depends upon inserting trial eigenvalues and observing the nature of the misbehavior of the solutions which are obtained. This misbehavior will change as a sequence of trial eigenvalues crosses the true eigenvalue. Thus in some examples $\Psi$ may go to $\infty$ as $\chi \to \infty$ for E too small, and $\Psi \to -\infty$ for $\chi \to \infty$ for E too large. The advantages of the method are that it

gives upper and lower bounds of comparable accuracy, the wave equation need not be separable, and the method can be applied to excited states as well as ground states. So far, series type solutions were used, so that no integrations or secular equations were required. Three examples are summarized: the quartic oscillator, the hydrogen molecule ion, and the helium atom. (auth)

**18756** UPPER AND LOWER BOUNDS IN SECOND-ORDER PERTURBATION THEORY AND THE UNSOELD APPROXIMATION. Lindner, Peter (Univ. of Uppsala); Loewdin, Per-Olov. Int. J. Quant. Chem., Symp. No. 2, 161-73(1968).

From Symposium on Atomic, Molecular, and Solid-State Theory and Quantum Biology, Sanibel Island, Florida. See CONF-680116.

Upper and lower bounds for the second-order energy in the Schrödinger perturbation theory are studied by means of operator inequalities and inner projections. It is shown that the variation problems associated with Hylleraas's upper bound and Hirschfelder–Prager's lower bound over a linear manifold have simple explicit solutions. The approach is tested numerically on some selected examples with good results. (auth)

**18757** RELATIONSHIP OF FLUX QUANTIZATION TO CHARGE QUANTIZATION AND THE FINE STRUCTURE CONSTANT. Jehle, Herbert (George Washington Univ., Washington, D. C.). Int. J. Quant. Chem., Symp. No. 2, 373-5(1968).

From Symposium on Atomic, Molecular, and Solid-State Theory and Quantum Biology, Sanibel Island, Florida. See CONF-680116.

An attempt is made to understand the relationship between $e^2$ and $\hbar$, i.e., to calculate the electromagnetic coupling constant. Simple leptons, the muons and electrons, are considered. (W.D.M.)

**18758** ERROR BOUNDS FOR QUANTUM-MECHANICAL PERTURBATION THEORY. Gordon, Roy G. (Harvard Univ., Cambridge, Mass.). Int. J. Quant. Chem., Symp. No. 2, 151-9(1968).

From Symposium on Atomic, Molecular, and Solid-State Theory and Quantum Biology, Sanibel Island, Florida. See CONF-680116.

A new method is described, which yields rigorous upper and lower bounds to the sums over excited states which occur in second-order quantum-mechanical perturbation theory. The only data required are values of certain expectation values over the wave function describing the ground state of the system, and the excitation energy of the first excited state which contributes to the sum. The error bounds are shown to be the most precise possible using only this information. As an example of the method, the optical polarizability of H and He atoms is calculated. The means of the upper and lower bounds in these cases have an accuracy of the order of 1%, although the rigorous error bounds can only guarantee an accuracy near 10%. A plausible, but nonrigorous argument is given for expecting this apparent greater accuracy of the mean value to hold in other cases as well. When wave functions of one or more excited states have been calculated, this additional information may be used to obtain more precise error limits for the perturbation sums. The method is applicable to a wide variety of problems which can be treated by perturbation theory. (auth)

**18759** SOME COMMENTS ON THE TREATMENT OF SYMMETRY PROPERTIES IN PERTURBATION THEORY. Loewdin, Per-Olov (Univ. of Florida, Gainesville. Univ. of Uppsala). Int. J. Quant. Chem., Symp. No. 2, 137-50(1968).

From Symposium on Atomic, Molecular, and Solid-State Theory and Quantum Biology, Sanibel Island, Florida. See CONF-680116.

The treatment of constants of motion and symmetry properties in partitioning technique and perturbation theory is briefly discussed. A constant of motion may be characterized by a set of project operators $\{Q_\lambda\}$ forming a resolution of the identity and leading to a splitting of the Hilbert space into orthogonal and noninteracting subspaces. It is shown that, in the partitioning technique, it is sufficient to consider only one such subspace at a time, which is a considerable simplification. The treatment may be extended to perturbation theory $\mathcal{H} = \mathcal{H}_0 + V$, and it is shown that the unperturbed Hamiltonian $\mathcal{H}_0$ enters the formalism only in the form of the reduced resolvents occurring in ordinary perturbation theory. It is emphasized that, even if the infinite-order expressions are unique, the finite-order expansions in the perturbation V are ambiguous, and the relation between various forms is studied. (auth)

**18760** CONTINUOUS SUPERSELECTION RULES. Piron, C. (Institut de Physique Theorique, Geneva). Helv. Phys. Acta, 42: 330-8(Apr. 1, 1969). (In French).

Starting from the calculus of propositions, a formalism is developed which allows one to treat continuous superselection rules, and some examples of applications of this formalism are given. (auth)

**18761** FIELD CONFIGURATIONS AND PARAMETERS THAT IDENTIFY STATES WITH j = 1. Fano, U. (National Bureau of Standards, Washington, D. C. Univ. of Chicago). pp 153-60 of Spectroscopic and Group Theoretical Methods in Physics, Block, F. (ed.). New York, John Wiley and Sons, Inc., 1968.

A particle (e.g., an atom, molecule, or nucleus) isolated in space and with nonzero angular momentum in its rest frame has a manifold of states with equal energy. Weak external fields can change these states into one another. Although analytical methods of identifying each state of given angular momentum and its transformations are available, qualitative understanding is limited, since parameters utilized for this purpose are often obscurely related to physical observables, and their ranges of variations are not easily outlined. Since many of the answers to questions concerning these states are well known for systems with $j = \frac{1}{2}$, the author treats here pure states with $j = 1$ and with intrinsic dipole and quadrupole moments, and general states with $j = 1$. Corresponding answers to the same questions with $j > 1$ are apparently unknown. (L.M.T.)

**18762** ISOTROPIC HARMONIC OSCILLATOR. Rose, M. E. (Univ. of Virginia, Charlottesville). pp 137-52 of Spectroscopic and Group Theoretical Methods in Physics. Block, F. (ed.). New York, John Wiley and Sons, Inc., 1968.

A number of interesting properties of the isotropic harmonic oscillator are investigated without attempting to apply them directly to the solution of a particular problem. This is done with the expectation that at least some of the results will be useful on occasions in the context of many physical problems in which the harmonic oscillator plays an important role. For the most part attention is restricted to the angular-momentum representation for the single-particle oscillator problem, since it is here that almost all new results appear. In addition, a few remarks are made in connection with the $SU_3$ group associated with the oscillator problem. (TSS)(auth)

**18763** RACAH COEFFICIENTS AND STATES WITH PERMUTATIONAL SYMMETRY. Moshinsky, M.; Chacon, E. (Univ. Nacional de Mexico, Mexico City). pp 99-117 of Spectroscopic and Group Theoretical Methods in Physics. Block, F. (ed.). New York, John Wiley and Sons, Inc., 1968.

The construction of n particle states in a three-dimensional harmonic-oscillator common potential is discussed, with the states classified by the irreducible representations of a physically relevant chain of groups which includes the n dimensional symmetric group $S_n$. It is shown that the matrix element of (n-1,n) can be given in terms of the usual Racah coefficients of $SU_2$ and their generalizations to unitary unimodular groups of higher order. The problem is outlined, first analyzing the procedure by which the states characterized by the canonical chain of unitary groups $U_n \supset U_{n-1} \supset \cdots \supset U_1$ can be constructed, and then discussing the projection technique for obtaining from them the states characterized by irreducible representations of $S_n$. It is then indicated how the projection operators could be explicitly applied, allowing then the detailed determination of states with permutation symmetry. (L.B.S.)

**18764** ALGEBRAIC STRUCTURES ASSOCIATED WITH THE 3-j AND 6-j SYMBOLS. Giovannini, A.; Smith, D. A. (Duke Univ., Durham, N. C.). pp 89-97 of Spectroscopic and Group Theoretical Methods in Physics. Block, F. (ed.). New York, John Wiley and Sons, Inc., 1968.

The natural ordered algebraic structures formed by certain arrays associated with 3-j and 6-j symbols are studied. (L.B.S.).

**18765** SEMICLASSICAL LIMIT OF RACAH COEFFICIENTS. Ponzano, G. (Princeton Univ., N. J.); Regge, T. pp 1-58 of Spectroscopic and Group Theoretical Methods in Physics. Block, F. (ed.). New York, John Wiley and Sons, Inc., 1968.

A derivation is given of a set of asymptotic formulas with separate ranges of validity, for the W coefficient. These formulas are a useful complement to the existing tables of Racah coefficients, since they are remarkably accurate for surprisingly low values of the angular momentum involved. (M.O.W.)

**18766** SPECTROSCOPIC AND GROUP THEORETICAL METHODS IN PHYSICS. Racah Memorial Volume. Bloch, F.; Cohen, S. G.; De-Shalit, A.; Sambursky, S.; Talmi, I. (eds.). New York, John Wiley and Sons, Inc., 1968. 472p. $22.00.

Separate abstracts were prepared for each of the 25 papers. (L.M.T.)

*For abstracts of individual papers see: 18409–18412, 18737, 18761–18765, 18829, 18883, 18937–18941, 18944, 18951, 19176, 19361, 19362, and 19364–19366.*

**18767** TESTING MODELS ON COMPRESSED SPECTRAL DATA. Haines, E. L. (California Inst. of Tech., Pasadena); Parker, R. H.; Gouw, R. Contract NAS 7-100. Nucl. Instrum. Methods, 69: 11-20(Mar. 1969).

A method is discussed by which one may extract information from compressed spectral data in terms of a physical model. The spectral data may come from mass, energy, or optical spectroscopy, gas chromatography, etc. A spectrum may be compressed into a finite sequence of orthogonal polynomial coefficients during data acquisition. The method used to extract the information from the compressed coefficients is the method of minimum-variance linear unbiased estimation. It provides a test of the validity of the chosen model, estimates of the parameters of the model, and an estimate of the covariance matrix of the parameters. (auth)

**18768** RELATIVISTIC TWO-BODY PROBLEM AND FINITE-DIFFERENCE CALCULATION. Kadyshevskii, V. G.; Mir-Kasimov, R. M.; Skachkov, N. B. (Joint Inst. for Nuclear Research, Dubna, USSR). Yadern. Fiz., 9: 212-23(Jan. 1969). (In Russian).

A special form for the finite-difference calculation is developed and applied to the relativistic Schrödinger difference equation. Solutions of this equation without an interaction are studied and the relativistic analogs for the Wronskians and for the Green functions are obtained. (auth)

**18769** FEYNMAN–SCHROEDINGER EQUATIONS AND THE METHOD OF STATISTICAL PERTURBATIONS. Dyad'kin, I. G. Zh. Vychisl. Mat. i Mat. Fiz., 8: 1269-79(Nov.-Dec. 1968). (In Russian).

A problem is set up for the eigenfunction in nonrelativistic quantum mechanics. It is shown that, by using gravitational potentials with known wave functions and steady-state levels, it is possible, despite propagator absence, to find migration schemes that take into account the main part of the gravitational potential, and find corrections only for the perturbation potential. It is pointed out how the suggested statistical theory of perturbation (set up with a Feynman propagator) differs from ordinary quantum mechanics. (R.V.J.)

**18770** ON THE THEORY OF THE MOTION OF CHARGED PARTICLES IN DIRECTIONALLY CONSTANT AND EXPONENTIALLY TIME-DEPENDENT MAGNETIC FIELD. II. SWITCH-OFF PROCESS WITH AND WITHOUT FRICTION. Koch, Eckhard (Arbeitsstelle fuer Statistische Physik, Leipzig). Beitr. Plasmaphys., 8: 355-69(1968). (In German).

The motion of a charged particle in a magnetic field is calculated for the following case: the spatially homogeneous magnetic field having a constant direction decreases exponentially in time (switch-off process); taken into account is the influence of the electric field and a friction force proportional to the particle velocity. The higher transcendental functions appearing in the exact solution are approximated in various ways in dependence on the values of argument and parameters. In this manner, approximated formulae of a very simple form are obtained for position, velocity, kinetic energy, and magnetic moment of the particle. The particle orbits are classified and their dependence on the initial values, parameters of the magnetic field, and the magnitude of the friction force is studied. A comparison between the results and a rectangular variation of the field shows that the latter is not a good approximation for a really exponentially decreasing field. A detailed investigation shows that the electric field induced by the time-dependent magnetic field has an important influence on the particle motion. (auth)

**18771** APPROXIMATE FORMULA FOR SCATTERING MATRIX IN MANY-STATE COLLISION PROBLEM: EXTENSION OF THE BII APPROXIMATION. Nakamura, Hiroki (Tokyo Univ.). J. Phys. Soc. Jap., 26: 614-20(Mar. 1969).

By dealing with the system of the coupled radial Schroedinger equations, the many-state collision problem is investigated. Replacing the Green operators of the radial differential Schroedinger operators by their δ-function parts, one can treat the problem successfully with some allowance for effects of all coupling potentials. The method employed in the author's previous papers is used to treat the nonlocal complex potentials. As a demonstration, a three-state case is considered and a new approximate formula for the scattering matrix is derived. In a certain limiting case, the formula obtained reduces to a corresponding one in the B(II) approximation proposed by Seaton for electron–atom collisions. This formula will be applicable to a wide class of collision processes. (auth)

**18772** OPTICS OF NATURALLY GYROTROPIC MEDIA IN THE PRESENCE OF A MAGNETIC FIELD. Eritsyan, O. S. (Inst. of Research in Physics, Erevan). Izv. Akad. Nauk Arm. SSR, Ser. Fiz., 3: 217-19(1968). (In Russian).

The propagation of electromagnetic waves in optically active media in the presence of a magnetic field is discussed. The dispersion relation is obtained and analyzed. The character of waves propagating in such a medium is analyzed. (auth)

**18773** ORDERED EXPANSIONS IN BOSON AMPLITUDE OPERATORS. Cahill, K. E.; Glauber, R. J. (Harvard Univ., Cambridge, Mass.). Phys. Rev., 177: 1857-81(Jan. 25, 1969).

The expansion of operators as ordered power series in the annihilation and creation operators a and $a^\dagger$ is examined. It is found that normally ordered power series exist and converge quite generally, but that for the case of antinormal ordering the required c-number coefficients are infinite for important classes of operators. A parametric ordering convention is introduced according to which normal, symmetric, and antinormal ordering correspond to the values s = +1, 0, –1, respectively, of an order parameter s. In terms of this convention it is shown that for bounded operators the coefficients are finite when $s > 0$, and the series are convergent when $s > \frac{1}{2}$. For each value of the order parameter s, a correspondence between operators and c-number functions is defined. Each correspondence is one-to-one and has the property that the function $f(\alpha)$ associated with a given operator F is the one which results when the operators a and $a^\dagger$ occurring in the ordered power series for F are replaced by their complex eigenvalues $\alpha$ and $\alpha^*$. The correspondence which is realized for symmetric ordering is the Weyl correspondence. The operators associated by each correspondence with the set of δ functions on the complex plane are discussed in detail. They are shown to furnish, for each ordering, an operator basis for an integral representation for arbitrary operators. The weight functions in these representations are simply the functions that correspond to the operators being expanded. The representation distinguished by antinormal ordering expresses operators as integrals of projection operators upon the coherent states, which is the form taken by the P representation for the particular case of the density operator. The properties of the full set of representations are discussed and are shown to vary markedly with the order parameter s. (auth)

**18774** DENSITY OPERATORS AND QUASIPROBABILITY DISTRIBUTIONS. Cahill, K. E.; Glauber, R. J. (Harvard Univ., Cambridge, Mass.). Phys. Rev., 177: 1882-1902(Jan. 25, 1969).

The problem of expanding a density operator $\rho$ in forms that simplify the evaluation of important classes of quantum-mechanical values is studied. The weight function $P(\alpha)$ of the P representation, the Wigner distribution $W(\alpha)$, and the function $\langle\alpha|\rho|\alpha\rangle$, where $|\alpha\rangle$ is a coherent state, are discussed from a unified point of view. Each of these quasiprobability distributions is examined as the expectation value of a Hermitian operator, as the weight function of an integral representation for the density operator and as the function associated with the density operator by one of the operator-function correspondences defined in the preceding paper. The weight function $P(\alpha)$ of the P representation is shown to be the expectation value of a Hermitian operator all of whose eigenvalues are infinite. The existence of the function $P(\alpha)$ as an infinitely differentiable function is found to be equivalent to the existence of a well-defined antinormally ordered series expansion for the density operator in powers of the annihilation and creation operators a and $a^\dagger$. The Wigner distribution $W(\alpha)$ is shown to be a continuous, uniformly bounded, square-integrable weight function for an integral expansion of the density operator and to be the function associated with the symmetrically ordered power-series expansion of the density operator. The function $\langle\alpha|\rho|\alpha\rangle$, which is infinitely differentiable, corresponds to the normally ordered form of the density operator. Its use as a weight function in an integral expansion of the density operator is shown to involve singularities that are closely related to those which occur in the P representation. A parametrized integral expansion of the density operator is introduced in which the weight function $W(\alpha,s)$ may be identified with the weight function $P(\alpha)$ of the P representation, with the Wigner distribution $W(\alpha)$, and with the function $\langle\alpha|\rho|\alpha\rangle$ when the order parameter s assumes the values s = +1, 0, –1, respectively. The function $W(\alpha,s)$ is shown to be the expectation value of the ordered operator analog of the δ function defined in the preceding paper. This operator is in the trace class for Res < 0, has bounded eigenvalues for Res = 0, and has infinite eigenvalues for s = 1. Marked changes in the properties of the quasiprobability distribution $W(\alpha,s)$ are exhibited as the order parameter s is varied continuously from s = –1, corresponding to the function $\langle\alpha|\rho|\alpha\rangle$, to s = +1, corresponding to the function $P(\alpha)$. Methods for constructing these functions and for using them to compute expectation values are presented and illustrated with several examples. One of these examples leads to a physical characterization of the density operators for which the P representation is appropriate. (auth)

**18775** SEARCH FOR A FUNDAMENTAL WAVE EQUATION. Ionescu-Pallas, N. J. (Inst. of Atomic Physics, Bucharest). Rev. Roum. Phys., 13: 811-13(1968).

A nonlinear generalization of the equation $[P_\mu P^\mu + (m_0c)^2]\,\psi - (\hbar q/ic)\,S^{-1}\,(\vec{E} + i\vec{H})\,\vec{S}\psi = 0$ was found in the sense in which Heisenberg generalized the Dirac equation. The advantage of generalizing the equation, of Feynman and Gell-Mann type, is obvious—one avoids in this way the redundant components and may operate easily with arbitrary spin particles. (TSS)

**18776** REFLECTION, REFRACTION, AND SCATTERING FOR NON-SPECIFIED WAVES. Bouman, J. (Technische Hogeschool, Delft, Netherlands). Physica, 35: 341-52(1967).

A general theory of waves, irrespective of their physical properties, is expounded. Only nonabsorbing media are considered. Next to the Snellius laws, which follow from the general aspects of waves, three principles are needed. From these the intensity of reflection may be found and the connection between scattering, the refractive index and the energy transport by the wave. The two formula's of Fresnel are closely connected with two kinds of scattering, the first one with isotropic scattering, the second formula with dipole scattering. Differential equations are not used. The general theory is applied to sound, light and x rays and to electron waves. (auth)

**18777** QUASI PROBABILITIES AND CORRELATION FUNCTIONS IN QUANTUM SYSTEMS. Bausch, R.; Schloegl, F.; Stahl, A. (Technische Hochschule, Aachen). Z. Phys., 220: 427-55(1969).

A general survey is given of the different methods that exist for the description of time correlations in quantum systems. A complete equivalence between all these methods is established on the basis of a consequent rule for the transcription of operator products into phase space. Particular attention is given to possible ambiguities in the definition of quantum mechanical Markov processes. The classical limit is discussed in detail. (auth)

**18778** NONINVARIANCE GROUPS FOR QUANTUM-MECHANICAL SYSTEMS. Aldrovandi, R.; Leal Ferreira, P. (Instituto de Fisica Teorica, Sao Paulo, Brazil). Nuovo Cim., Lett., 1: 317-20(Feb. 21, 1969).

Examples of nonmaximally degenerated systems amenable to a simple group-theoretical treatment are studied. In the cases under consideration, the eigenvalue problem can be solved by means of the group $SO_{2,1} \times SO_3$, as a noninvariance group of the Hamiltonian. The $SO_3$ group is connected with the orbital angular momentum and therefore the $SO_{2,1} \times SO_3$ group may be considered as an invariance group of the angular momentum. (TSS)

# PHYSICS (HIGH ENERGY)

## Particle Interactions and Properties (Experimental)

*Refer also to abstracts 18452 and 19083.*

**18779** EXPERIMENTAL RESEARCH PROGRAM ON THE NEW ACCELERATOR. Sulyaev, R. M. Vestn. Akad. Nauk SSSR, No. 8, 76-81(Aug. 1968). (In Russian).

The startup of the Serpukov accelerator has made it possible to predict and verify the behavior of interaction cross-sections of particles and antiparticles at energies which have been unavailable earlier. Fundamental principles of quantum field theory can be confirmed. The systematics of elementary particles can be developed further, since particles having large masses and high quantum numbers will be available for study. Exploratory experiments can be run in a search for new fundamental particles such as quarks which are the basic structural elements of matter, intermediate bosons which can serve as transfer agents of weak interactions similar to mesons in strong interactions, particles with elementary magnetic charge, and heavy leptons. It should be possible to create a beam of high energy neutrinos and to obtain new important results in this field. A great deal of specialized equipment is being prepared such as propane and liquid hydrogen bubble chambers (0.5 $m^3$ volume) with superconducting magnet, a six-meter magnetic spectrometer with spark chambers, Cherenkov selectors, and hodoscopic systems. These systems will be coupled to computers which will analyze the data obtained from experiments on various particle beams. (TTT)

### *Electromagnetic*

*Refer also to abstracts 18463 and 18757.*

**18780** (DESY-68/53) ELECTROPRODUCTION OF PIONS NEAR THE DELTA(1236) ISOBAR AND THE FORM FACTOR $G_M^*(q^2)$ OF THE $(\gamma,N,\Delta)$-VERTEX. Bartel, W.; Dudelzak, B.; Krehbiel, H.; McElroy, J.; Meyer-Berkhout, U.; Schmidt, W.; Walther, V.; Weber, G. (Deutsches Elektronen-Synchrotron, Hamburg (West Germany). Hamburg Univ. (West Germany). II. Institut fuer Experimentalphysik). Oct. 1968. 15p. Dep.

The cross section for inelastic electron–proton scattering was measured at incident electron energies of 1.5 to 6 GeV by magnetic analysis of the scattered electrons at angles between 10 and 35°. For invariant masses of the hadronic final state $W \leq 1.4$ GeV, the measured spectra are compared with theoretical predictions for electroproduction of the $\Delta$ (1236) isobar. The magnetic dipole transition form factor $G_M^*(q^2)$ of the $(\gamma N\Delta)$-vertex is derived for momentum transfers $q^2 = 0.2 - 2.34$ $(GeV/c)^2$ and found to decrease more rapidly with $q^2$ than the proton form factors. (auth)

**18781** ANALYSIS OF THE RESULTS OF A MEASUREMENT OF THE MAGNETIC MOMENT OF THE $\Lambda^0$ HYPERON. Charriere, Gerard (Univ. of Lausanne, Switzerland). Helv. Phys. Acta. 42: 339-60(Mar. 1, 1969). (In French).

A method is described for the kinematic reconstruction of 874 $\Lambda$ decays observed in nuclear emulsions. Their angular distribution is studied in order to determine the $\Lambda$ magnetic moment. Selecting 151 events, $\mu_\Lambda = -0.50 \pm 0.28$ nuclear magneton is obtained. A discussion of the systematic errors is given and the method of selection of the events is justified. (auth)

**18782** TOTAL ETA–NUCLEON CROSS SECTION BY PHOTOPRODUCTION OF ETA–MESONS IN COMPLEX NUCLEI. Bacci, C. (Istituto Nazionale di Fisica Nucleare, Rome); Salvini, G.; Baldini-Celio, R.; Eponeshnikov, V. N.; Mencuccini, C.; Reale, A.; Spinetti, M.; Zallo, A. Nuovo Cim., Lett., 1: 391-5(Mar. 11, 1969).

The results of an experiment performed at Frascati with the 1.1 GeV electron synchrotron on the photoproduction of mesons ($\eta$) in complex nuclei is reported. For nuclei of different atomic weight the reaction is $\gamma$ + nucleus → $\eta$ + residual nucleus. This was studied by measuring the differential cross section $d\sigma(A)/d\Omega$ for this process. A large $\eta$–nucleon interaction cross section $\sigma$ is found at an $\eta$–nucleon cms momentum of 250 MeV/c. The relation $\sigma = \sigma_t + \sigma_{sc} \geq 65$ mb expresses this cross section. (J.F.P.)

**18783** INVESTIGATION OF ELECTRON–POSITRON SHOWERS DUE TO $\gamma$ QUANTA WITH THE ENERGY 100, 200, 500, AND 2000 MeV. Slovinski, B.; Strugalskii, Z. S.; Yanovskaya, B. (Joint Inst. for Nuclear Research, Dubna, USSR). Yadern. Fiz., 9: 120-5(Jan. 1969). (In Russian).

Development of electron-positron showers due to $\gamma$ quanta with the energies $E_\gamma$ = 100, 200, 500, and 2000 MeV in liquid xenon is studied. Experimental data on the fluctuations in the development of showers are obtained. (auth)

**18784** INVESTIGATION OF THE $\rho$-MESON RESONANCE WITH ELECTRON–POSITRON COLLIDING BEAMS. Auslander, V. L.; Budker, G. I.; Pakhtusova, E. V.; Pestov, Yu. N.; Sidorov, V. A.; Skrinskii, A. N.; Khabakhpashev, A. G. (Inst. of Nuclear Physics, Novosibirsk, USSR). Yadern, Fiz., 9: 114-19(Jan. 1969). (In Russian).

A detailed analysis is presented of the experimental data on measurement of $\pi$-pair production cross section in the experiments with electron-positron colliding beams in the region of the $\rho$-resonance. Particular attention is given to the problem of an objective identification of $e^+e^-$-scattering events and events of $\pi$-pair production. As a result the $\rho$-resonance parameters are obtained: m = 754 ± 9 MeV, $\Gamma$ = 105 ± 20 MeV, and maximum cross section of $e^+e^-$-annihilation into $\pi$-pair $\sigma_\rho = 1.3 \pm 0.2$ $\mu$bn which corresponds to branching ratio for leptonic decay of the $\rho$-meson $B = (5.0 \pm 1.0) \cdot 10^{-5}$ and its coupling constant $\gamma_\rho^2/4\pi = 0.64 \pm 0.11$. (auth)

**18785** ANALYSIS OF GENETICALLY CONNECTED ELECTRON–PHOTON CASCADES WITH ENERGY HIGHER THAN $10^{14}$ eV. Cherdyntseva, K. V.; Rakobolskaya, I. V.; Nikolskii, S. I. (Lebedev Inst. of Physics, Moscow. Moscow State Univ.). Yadern. Fiz., 9: 152-9(Jan. 1969). (In Russian).

A group of electron-photon cascades resulting from nuclear interaction in the air above the device is found by means of Roentgen films. The event can be explained as a production of fireball with large Lorentz factor (10 to 40) in cms. (auth)

**18786** ELECTRIC DIPOLE MOMENT OF THE NEUTRON. Cohen, Victor W. (Brookhaven National Lab., Upton, N. Y.); Nathans, Robert; Silsbee, H. B.; Lipworth, Edgar; Ramsey, Norman F. Phys. Rev., 177: 1942-5(Jan. 25, 1969).

An attempt was made to observe an electric dipole moment of the neutron by performing a neutron-beam magnetic-resonance experiment with a strong electric field superimposed parallel to the uniform magnetic field. Significant limits of error of the measurement based upon probability considerations cannot be assigned because of systematic errors larger than those expected from statistics. The results are not consistent with any absolute value appreciably greater than $10^{-21}$ e cm and are consistent with other recent measurements. (auth)

**18787** MEASUREMENTS OF ELASTIC ELECTRON–DEUTERON SCATTERING AT HIGH MOMENTUM TRANSFERS. Elias, J. E. (Massachusetts Inst. of Tech., Cambridge); Friedman, J. I.; Hartmann, G. C.; Kendall, H. W.; Kirk, P. N.; Sogard, M. R.; Van Speybroeck, L. P.; de Pagter, J. K. Contract AT(30-1)-2098. Phys. Rev., 177: 2075-92(Jan. 25, 1969).

Measurements of cross sections for elastic electron-deuteron scattering were made over a range of four-momentum transfers squared from 14.4 to 35.4 $F^{-2}$. Incident electrons of energies 4.419 and 4.910 BeV were scattered from a liquid-deuterium target and detected in coincidence with the recoil deuterons. Measurements of a combination of the charge and electric quadrupole moment form factors were obtained from the cross sections, and detailed comparisons were made with theoretical predictions based on wave functions derived from nucleon-nucleon scattering experiments. Good agreement was found with a few of the wave functions used. Theoretical estimates of meson-exchange-current enhancements and relativistic effects were also compared to the data. (auth)

**18788** INELASTIC NUCLEAR INTERACTIONS OF HIGH-ENERGY ELECTRONS AND MUONS IN EMULSION. Thompson, Richard L. (Univ. of Washington, Seattle); Lord, J. J.; Kirk, James A.; Nelson, Martin E.; Piserchio, Robert J. Phys. Rev., 177: 2022-8(Jan. 25, 1969).

An experiment was carried out to examine the inelastic nuclear interaction properties of high-energy electrons and muons in emulsion. A study was made of interactions produced by 10.5-GeV muons and 10.0- and 16.0-GeV electrons. Total and differential cross sections were measured and compared with calculations carried out with the formulation of Hand and Wilson for inelastic lepton scattering. On the basis of the calculations, the ratio of electron to muon total cross sections was found to be 3.5 : 1, whereas experimentally the ratio was measured to be 2.18 ± 0.40 for the 10-GeV leptons. To explain the total cross section for electrons, an average scalar-photon contribution equal to 12% of the transverse-photon cross section is needed, which is consistent

with other experiments. The muon cross section was found to be significantly larger than expected, and it cannot be explained by a similar scalar-photon contribution. The energy dependence of the total cross sections is in agreement with theory, as are the angular distributions of the scattered leptons. (auth)

**18789** SEARCH FOR MULTIPLY CHARGED DIRAC MAGNETIC POLES. Fleischer, R. L. (General Electric Research and Development Center, Schenectady, N. Y.); Jacobs, I. S.; Schwarz, W. M.; Price, P. B.; Goodell, H. G. Phys. Rev., 177: 2029-35(Jan. 25, 1969).

A 265,000-G pulsed magnetic field and plastic track detectors were used in an attempt to extract and observe magnetic monopoles from manganese nodules formed on the floor of the Southern Ocean. Because of their low growth rate, these nodules compress a long period of possible monopole trapping (≈ 300,000 years) into small volumes of material, making possible in this search an (area) × (time) factor of $\approx 3 \times 10^{14}$ cm²-sec. The detector system has the merit of containing zero background, making possible a sensitivity such that any multiple of Dirac's original charge of up to 120 could have been detected. The absence of monopoles in the material searched sets new limits on the abundance of multiply charged monopoles and of monopoles that are too massive ($> 3m_{proton}$) to have been produced in previously reported accelerator experiments. The results imply that at no energy up to at least $2 \times 10^{17}$ eV are the primary cosmic rays dominantly composed of magnetic monopoles. (auth)

**18790** STUDY OF $K^-p$ INTERACTIONS AT 4.1 AND 5.5 GeV/c: FINAL STATES WITH TWO CHARGED PARTICLES AND A VISIBLE Λ. Mott, J. (Northwestern Univ., Evanston, Ill.); Ammar, R.; Davis, R.; (and others). Phys. Rev., 177: 1966-90 (Jan. 25, 1969).

The results described were obtained from an analysis of bubble-chamber pictures of $K^-p$ interactions at incident momenta of 4.1 and 5.5 GeV/c. The results are reported on quasi-two-body final states, which are observed to be predominantly peripheral. In the final states $\Lambda\rho$, $\Lambda\omega$, $\Lambda\phi$, and $Y_1^{*+}(1385)\pi^-$, the exchange mechanisms were investigated in terms of the density-matrix formalism. In general, vector-meson exchange appeared to be dominant, and in particular the decay distributions of the $Y_1^{*+}(1385)\pi^-$ final state were in good agreement with the predictions of the Stodolsky-Sakurai model. Several reactions show small backward peaks expected from baryon exchange. The prediction of the independent quark model and other symmetry schemes that the forward cross sections for $\Lambda\rho^0$ and $\Lambda\omega$ production should be equal is well satisfied by the present data. Measurements of the properties of various resonant states are also reported. A mass and width were found for the $Y_1^*(1695)$ of M = 1700 ± 20 MeV, Γ = 130 ± 25 MeV. The dominant decay mode is $\Lambda\pi^+$, but limits are placed on other possible channels. (auth)

## Weak

*Refer also to abstract 18872.*

**18791** (AD-672919) EXPERIMENTAL STUDY OF THE 2 NEUTRAL-PION DECAY OF THE LONG-LIVED NEUTRAL K-MESON. Technical Report. Wheeler, Paul C. (Princeton Univ., N. J. Elementary Particles Lab.). June 14, 1968. Contract N00014-67-A-0151. 151p. CFSTI.

The 2 neutral-pion CP-violating decay of the neutral-K2-meson was studied in a recent experiment at the Princeton-Pennsylvania Accelerator. The energy spectrum of generated gamma-rays was obtained for the center-of-mass system of the neutral-K2 and used to measure the branching ratio (neutral-K2 to 2 neutral-pions)/(neutral-K2 to all modes). An upper limit of 0.0031 was obtained by normalizing to the neutral-K2 to 3 neutral-pion decay mode. (auth)

**18792** MUON CAPTURE IN GASEOUS HYDROGEN. Alberigi Quaranta, A. (Univ., Bologna. Istituto Nazionale di Fisica Nucleare, Bologna); Bertin, A.; Matone, G.; Palmonari, F.; Torelli, G.; Dalpiaz, P.; Placci, A.; Zavattini, E. Phys. Rev., 177: 2118-32(Jan. 25, 1969).

An experiment to measure the muon nuclear capture rate in ultrapure gaseous hydrogen (8 atm, 293°K) was performed using a special target in which a system of gas proportional counters, working with the pure hydrogen of the target itself, were operating. Neutrons from the capture reactions were detected using a scintillation-counter technique, and the γ-ray background was eliminated by pulse-shape discrimination. The working conditions ensured that the captures were taking place in μp atomic systems in a singlet total-spin state. The experimental result is $\Lambda_{expt} = 651 \pm 57$ sec$^{-1}$, which has to be compared with the theoretical rate $\Lambda_{s.\,theor} = 626 \pm 26$ sec$^{-1}$. From the experimental capture rate, and within the framework of the currently accepted theory, we have obtained for the induced pseudoscalar coupling constant $g_p = (-7.3 \pm 3.7)g_V$. The results of the present experiment are analyzed, together with results obtained from stopping negative muons in liquid hydrogen. (auth)

**18793** SEARCH FOR A NEUTRAL WEAK INTERACTION VIA $\bar{\nu}_e$ DISSOCIATION OF DEUTERONS. Munsee, J. H. (Case Western Reserve Univ., Cleveland); Reines, F. Phys. Rev., 177: 2002-8(Jan. 25, 1969).

An attempt was made to observe the dissociation of the deuteron by electron antineutrinos in order to test the theory of the neutral weak-interaction current. This event could be recognized by the detection of both disintegration products, the neutron and the proton. A deuterated liquid scintillator loaded with gadolinium to provide energetic-neutron-capture γ rays was used in this search. The signature for the event would be a prompt "proton" pulse followed by a coincidence between two crystals which signaled neutron capture. The crystal energy gates were set between 0.75 and 6.25 MeV, and the liquid scintillator was set for a light output equal to that produced by electrons > 0.20 MeV and < 0.59 MeV. During 55.5 h of runs near one of the Savannah River Plant reactors, the cross section for this process was determined to be $< (1.7 \pm 1.4) \times 10^{-42}$ cm², a limit which is to be compared with a maximum theoretical expectation of $1.3 \times 10^{-44}$ cm² and a previous experimental limit of $10^{-40}$ cm². (auth)

**18794** SEARCH FOR THE DECAY $K_S^0 \rightarrow \mu^+\mu^-$. Stutzke, R. D.; Abashian, A.; Jones, L. H.; Mantsch, P. M.; Orr, J. R.; Smith, J. H. (Univ. of Illinois, Urbana). Phys. Rev., 177: 2009-15 (Jan. 25, 1969).

A search for the decay $K_S^0 \rightarrow \mu^+\mu^-$ has been completed at the Argonne zero-gradient synchrotron. No event has been found. The upper limit for the branching ratio is $\Gamma(K_S^0 \rightarrow \mu^+\mu^-)/\Gamma(K_S^0 \rightarrow \text{all decays}) < 9.7 \times 10^{-5}$. (auth)

## Strong (Baryon-Induced)

*Refer also to abstract 19341.*

**18795** (CONF-671217-, pp 589-695) ELEMENTARY-PARTICLE PHYSICS: EXPERIMENTS. (Department of Atomic Energy, Bombay (India). Cosmic Ray Committee).

This review of experiments in elementary particle physics covers baryon and meson resonances, hyperfragments, and an estimation of the primary energy in single collision interactions with a nucleon. The characteristics of particle production in the interactions of 22.8-GeV/c protons with light nuclei in emulsion, the emission of fast deuterons and tritons from 24-GeV/c proton interactions, the energy spectrum of pions and protons in π + N collisions at 17 GeV/c and p + p collisions at 24 GeV/c, $\bar{p}$ + N interactions at 5 GeV/c, are discussed. The re-emission of antiprotons from the interactions of antiprotons at 5 GeV/c, the basic features of quasi-two-body channels produced in $K^-$ + p interactions at 6 GeV/c, transverse momentum in 17.2 GeV pion–nucleon interactions, and coherent production of pions in high-energy $\bar{\pi}$ interactions are considered. Also considered are binding energies and $\pi^+$ decay of light hyperfragments, the ratio of nonmesic to $\pi^-$-mesic decay of light hyperfragments, final state interactions in the decay of light hyperfragments, the frequency of He-8 nuclei among hammer tracks in nuclear emulsions, and the bubble chamber film analysis facility at T.I.F.R. (J.F.P.)

**18796** (JINR-P2-4258) PRODUCTION OF NUCLEI WITH MASS NUMBERS A = 2 – 4 IN COLLISIONS OF HIGH ENERGY PARTICLES WITH THE COMPLEX NUCLEI (MAIN EXPERIMENTAL RESULTS AND THEIR INTERPRETATION). Eliseev, S. M. (Joint Inst. for Nuclear Research, Dubna (USSR). Lab. of Theoretical Physics). 1969. 34p. (In Russian). Dep.

Experimental data on the production of deuterons, tritons and α particles in collisions of particles with nuclei are reviewed. Different models of light nuclei production (Bulter-Pearson model, fluctuation model etc.) are also considered. (auth)

**18797** CASCADE AND EVAPORATION PROCESSES IN RELATIVISTIC NUCLEUS-NUCLEUS AND PROTON-NUCLEUS INTERACTIONS. Otterlund, I. (Lund Univ., Sweden). Ark. Fys., 38: 467-87(1968).

Nucleus-nucleus collisions produced in nuclear emulsions by heavy cosmic ray primaries were analyzed. The charge of the primaries fell in the interval $3 \leq Z \leq 26$ and the kinetic energy of the primaries in the interval $2 \approx E \approx 15$ GeV/nucleon. The cascade and evaporation processes were studied in proton-nucleus collisions at 6.2 GeV and 22.5 GeV. It was found that in collisions with heavy target nuclei on the average more particles are emitted from the target nucleus in a nucleus-nucleus collision than in a

proton-nucleus collision. The relation between size of the cascade developed in the target nucleus and number of particles evaporated is discussed and compared to a theoretical calculation for proton-nucleus collisions at 1840 MeV. It is shown that in proton-nucleus collisions the connection between the number of grey and black prongs is not strongly dependent on the energy of the incident proton, if this is greater than about 2 GeV. A comparison between the proton-nucleus and the nucleus-nucleus collisions shows that a cascade nucleon transfers on the average more excitation energy to the target nucleus in a proton-nucleus collision than in a nucleus-nucleus collision. Furthermore, it is shown that approximately the same numbers of black track-producing particles are emitted in nucleus-nucleus and proton-nucleus collisions despite the large difference in the number of cascade particles produced in the two different kinds of interactions. The number of black track-producing particles seems also to be independent of the number of pions produced in the interaction at the energies considered in this investigation. This may partly be explained by the production of excited nucleons in the high energy interaction. The results show that the second stage of the interaction process is essentially independent of the nature of the incident particles. (auth) (Swed)

**18798** SEARCHES FOR THE PROCESS OF FIREBALL GENERATION IN NUCLEAR INTERACTIONS OF PROTONS WITH ENERGIES 20 AND 23 GeV. Zhdanov, G. B.; Tret'yakova, M. I.; Chernyavskii, M. M. (Lebedev Inst. of Physics, Moscow). JETP Lett. (USSR) (Engl. Transl.), 8: 408-12(Dec. 20, 1968).

Translated from Zh. Eksp. Teor. Fiz., Pis'ma Redaktsiyu, 8: 659-65(Dec. 5, 1968).

To assess the possibility of fireball formation the quasinucleon interactions of protons with energies 20 and 23 GeV registered in emulsions exposed to the CERN accelerator in a pulsed magnetic field (180 kOe) were analyzed. Approximately 160 interactions of the quasinucleon type with multiplicities n = 5–8, of which about 40 contained two protons in the final state were selected. Besides the emission angles of all the charged secondary particles, their momenta were measured, and a determination was made of the sign of the charge and the nature of the particle. (J.F.P.)

**18799** STUDY OF HYPERFRAGMENTS PRODUCED IN ANTIPROTON INTERACTIONS AT 5 GeV/c WITH EMULSION NUCLEI. Todorovic, Z. (Centre de Recherches Nucleaires de Strasbourg, Cronenbourg, France); Gerber, J. P.; Bechdolff, A.; Annoni, H.; Baumann, G. Nuovo Cim., 60A: 101-7(Mar. 1, 1969). (In French).

The hyperfragment production by antiprotons of 5 GeV/c was studied. A production frequency of $(2.35 \pm 0.49) \cdot 10^{-3}$ was found. This value is greater than in the case of proton interactions of similar energy. (auth)

**18800** ENERGY CHARACTERISTICS OF COSMIC PARTICLE INTERACTIONS WITH CARBON ATOMIC NUCLEI. Alibekov, M. I.; Babaev, M. K.; Eremenko, Yu. A.; Lukin, Yu. T.; Takibaev, Zh. S. (Inst. of Nuclear Physics, Tashkent). Izv. Akad. Nauk SSSR, Ser. Fiz., 32: 378-9(Mar. 1968). (In Russian).

A device consisting of a Wilson chamber, ionization calorimeter, and 7 g · cm² thick target in the chamber was used for estimating the inelasticity coefficients for 45 showers with primary charged particle energy $\langle E_0 \rangle$ = 300 GeV and charged particle multiplicity $\langle n_s \rangle$ = 8.5. The distribution according to magnitudes $K_{\pi^0}$ (energy transmitted to $\pi^0$ mesons), $K_{\pi^\pm}$ (energy transmitted to charged particles), and K is given in graphical form. Considering that at high elevation (700 g · cm$^{-2}$) the ratio of proton number to neutron was $N_p/N_n = 1.22$ it was possible to estimate the portion of $\pi$ mesons among the primary particles as $N_\pi/N_{nucl} = 0.25 \pm 0.08$, $N_\pi/N_p = 0.46 \pm 0.12$ and probability of nucleon recharge equal to 0.67. With the minimum magnitudes $\langle p_{\perp nucl} \rangle$ = 1.4 GeV/c. (R.V.J.)

**18801** DOUBLE ELASTIC PROTON SCATTERING ON POLARIZED PROTON TARGET. Bystricky, J.; Cech, J.; Janout, Z.; Kazarinov, Yu. M.; Lehar, F.; Parfenov, L. B. (Joint Inst. for Nuclear Research, Dubna, USSR). Phys. Lett., 28B: 572-4(Feb. 3, 1969).

The triple scattering depolarization transfer parameter $D_t$ in elastic p-p scattering was measured at the energy of 660 MeV using a polarized proton target. All measurements were made with the help of an optical spark chamber. The following results have been obtained: $D_t$ (90°) = D (90°) = 0.54 ± 0.10; $D_t$ (130°) = D (50°) = 0.72 ± 0.11. (auth)

**18802** MEASUREMENT OF CROSS SECTIONS WITH NEUTRONS AS TARGETS. II. Widgoff, M. (Brown Univ., Providence); Cormack, A. M.; Koehler, A. M. Phys. Rev., 177: 2016-22(Jan. 25, 1969).

A measurement of the proton-neutron total cross section $\sigma_{pn}$ by the Chew-Low extrapolation technique, carried out with protons of 89 MeV incident on deuterium, is described. The purpose of the experiment was to provide an additional test of the Chew-Low method, supplementing a previous test near 160 MeV. The method is difficult to apply, but the measured values of $\sigma_{pn}$ around 89 MeV again give sufficiently good agreement with $\sigma_{np}$ values obtained by direct scattering methods to give confidence in the technique for the determination of the neutron-neutron cross section. (auth)

**18803** EXPERIMENTAL TEST OF THE IMPULSE APPROXIMATION IN pd INELASTIC SCATTERING AT 200 MeV. Brown, C. N.; Thorndike, E. H. (Univ. of Rochester, N. Y.). Phys. Rev., 177: 2067-74(Jan. 25, 1969).

Inelastic pd interactions were studied at 200 MeV by bombarding a target of liquid deuterium with a 92% polarized proton beam. The directions and energies of the two scattered protons were measured using thick plastic scintillation counters. Four types of cross sections were studied: (1) the two-proton coincidence rate, $d\sigma/d\Omega_1 d\Omega_2$; (2) the fully differential cross section, $d\sigma/d\Omega_1 d\Omega_2 dE_1$; (3) the single-arm charged-particle yield, $d\sigma/d\Omega_1$; and (4) "singlet deuteron" production. These measured cross sections, and previously reported 145-MeV data of Knuckes et al., are compared with impulse-approximation theories. Our treatment of the spectator model differs from that used previously in that we have treated the kinematics relativistically. The first two cross sections are dominated by quasifree pp scattering. Impulse theories which include final-state interaction terms give much better fits to these data than the simple spectator model gives, but there remains an overestimation of the observed cross section in the quasifree pp region of about 10%, and the fit in other regions is still qualitative only. The single-arm yield is described very well by a simple sum rule giving the yield as the sum of the free pp and pn differential cross sections. A final-state-interaction enhancement in the two-proton rate, usually referred to as the "singlet deuteron," was observed in the region of 105° cm pd elastic scattering having a cross section of 0.3 mb/sr². (auth)

## *Strong (Meson-Induced)*

*Refer also to abstracts 18795 and 18796.*

**18804** (COO–1195-157) PRODUCTION OF THREE CHARGED PIONS IN PI MINUS PROTON INTERACTIONS AT FIVE GeV. Terreault, Bernard (Illinois Univ., Urbana. Dept. of Physics). Feb. 1969. Contract AT(11-1)-1195. 169p. Dep. CFSTI.

Thesis.

The 72" bubble chamber at the Lawrence Radiation Laboratory has been exposed to a beam of 5 BeV/c $\pi^-$ mesons and 150,000 photographs have been taken. As a part of this experiment, the interactions producing four charged particles in the final states have been measured and the reaction $\pi^- p \rightarrow p\pi^+\pi^-\pi^-$ has been studied, with the emphasis placed on the three pions system. The cross section for this reaction was found to be 1.80 ± 0.45 mb. For the final analysis 6300 events (.286 ± .071 μb/event) were selected. The mass spectra of the different particle combinations have been investigated. The reaction has been found to be characterized by the following features: Strong production of well-known resonances, in particular the $\rho^0$ (35% of the events), $N^{*++}_{1236}$ (30%) and various $N^{*0}$'s; A broad enhancement in the $\pi^+\pi^-\pi^-$ and in the $\rho^0\pi^-$ mass between 1.0 and 1.4 BeV, associated with momentum transfers to the proton characteristic of diffraction-scattering. The data below the $A_2$ mass (1.26 BeV) are consistent with this enhancement being a state of spin-parity $1^+$ with $J_z = 0$ along the incident pion direction. It does not appear to be entirely due to a Deck-type kinematic effect. Three peaks of marginal statistical significance in the $\pi^+\pi^-\pi^-$ mass, with masses (and widths) 1.06 BeV (40 MeV), 1.17 BeV (60 MeV) and 1.475 BeV (30 MeV). Peripheral production of a meson of mass 1.62 BeV, width about 100 MeV, decaying into $\pi^+\pi^-\pi^-$, and known as the $A_3$ meson. Its spin-parity is most probably $2^-$. (auth)

**18805** (COO-1195-158) $A_2$ MESON PRODUCTION IN $\pi^- p$ INTERACTIONS AT 5 GeV. Schafer, Elton Duane (Illinois Univ., Urbana. Dept. of Physics). Jan. 1969. Contract AT(11-1)-1195. 165p. Dep. CFSTI.

Thesis.

The meson ($A_2$) was studied from data obtained from $\pi^-$ + p interactions at 5 GeV/c in the Alvarez liquid hydrogen bubble chamber. The $\rho\pi$ decay mode in the 4-constraint $p\pi^+\pi^-\pi^-$ final state is treated in detail. The spin-parity analysis of the $A_2$ yields results consistent with a $J^P = 2^+$ assignment. The production of this resonant state appears to be confined essentially to the momentum transfer range $0.125 \leq t \leq 2$ GeV$^2$. (J.F.P.)

**18806** (JINR-P1-4271) INVESTIGATION OF THE $\rho^+$ AND $N^{*++}$ RESONANCE PRODUCTION IN TWO-PRONGED $\pi^+ p$ INTERACTIONS AT 2.34 GeV/C. Angelov, N.; Gramenitskii, I. M.;

Kanazirski, Kh.; Moiseev, A. M.; Prokesh, A.; Tikhonova, L. A.; Fenyuk, A. B.; Shafranov, M. D. (Joint Inst. for Nuclear Research, Dubna (USSR). Lab. of High Energy). 1969. 27p. (In Russian). Dep.

The experimental data on the investigation of the $\rho^+$-meson and $N^{*++}$ isobar production as well as the differential production cross sections of these resonances, angular distributions of their decay products, and the dependence of the spin matrix density elements on the four-momentum are presented. The comparison with some OPE models is made. (auth)

**18807** (SLAC-92) ANALYSIS OF MUON HYDROGEN BUBBLE CHAMBER EXPERIMENTS. Perl, Martin L. (Stanford Linear Accelerator Center, Calif.). Dec. 1968. Contract AT(04-3)-515. 8p. Dep. CFSTI.

Basic data for the consideration of muon exposures in liquid hydrogen bubble chambers at the Stanford Linear Accelerator Center for studying muon + proton inelastic reactions are presented. The improvement in the data rate by using a very large hydrogen bubble chamber is shown. The relevant properties of the SLAC muon beam are discussed, and the inelastic event rate to be expected in a SLAC bubble chamber is given. The event rate is given for a very large hydrogen bubble chamber such as the Argonne National Laboratory 12-foot chamber or the 25-foot chamber proposed by Brookhaven National Laboratory. (auth)

**18808** T = 2 PION-PION SCATTERING. Albright, J. R.; Bradley, R. H.; Harms, B. C.; Harrison, W. C.; Hunter, R. E.; Lannutti, J. E.; Reynolds, B. G.; Sims, W. H.; Wieckowicz, R. P. (Florida State Univ., Tallahassee). Nuovo Cim., 60A: 1-9(Mar. 1, 1969).

Angular distributions for $\pi^-\pi^-$ scattering were studied using the reaction $\pi^-p \to \pi^-\pi^-\pi^+p$ at 2.26 GeV/c. The T = 2 D-wave phase shift is discussed. (auth)

**18809** COHERENT PRODUCTION OF PIONS 17.2 GeV PION-NUCLEUS INTERACTIONS IN EMULSION NUCLEI. Dubey, D. P.; Kohli, J. M.; Singh, M. B. (Panjab Univ., Chandigarh, India). Proc. Indian Acad. Sci., Sect. A, 68: 209-217(Oct. 1968).

The coherent production of pions at 17.2 GeV in pion interactions with nuclei was studied using the nuclear emulsion technique. The kinematical selection of such events was made out of three prong events in which all the prongs were identified as pions. The mean free path of coherent events was 65 meters. It was found that diffraction dissociation takes place with lighter nuclei, whereas the Coulomb dissociation plays a major role in the case of heavier emulsion nuclei. (auth)

**18810** SEARCH FOR HEAVY MESON RESONANCES IN $\pi^-p$ COLLISIONS AT 17 GeV. Azimov, S. A.; Rechitskii, I. V.; Til, A.; Chudakov, V. M. (Inst. of Nuclear Physics, Tashkent). Yadern. Fiz., 9: 126-33(Jan. 1969). (In Russian).

Missing mass (M) distribution investigated on 204 stars detected in nuclear emulsion after 9 km of initial $\pi^-$-meson tracks were scanned. The stars satisfy certain selection rules as $\pi^-p$-collisions with slow recoil protons and with 3 or 5 fast secondary charged particles. A method is presented for construction of the background curve in the presence of the pion-nucleus collisions in the experimental data. There is an excess of events 23.4 ± 9.8 over the background curve in the region $2.9 < M < 3.5$ GeV. This excess is assumed to be related to the reactions $\pi^-p \to pO^-$. The cross section is about 0.8 mbarn. By means of the original method in the region $2.9 < M < 3.5$ GeV azimuthal correlations were found with satisfactory statistics—a predominant coplanar configuration of the shower particles. This fact is qualitatively explained with assumption about production of heavy resonances. No azimuthal correlations are present out of the missing-mass region 2.9 to 3.5 GeV. Selecting the stars with high complanarity $\beta$ the peak in the missing-mass distribution is obtained that is on the level of 3.3 standard deviations. The observed specific M dependence of the latitudinal angular distributions is additional confirmation of the hypothesis about production of heavy resonances. (auth)

**18811** EFFECT OF NUCLEAR FORM FACTOR IN THE $\pi^+$-MESON CHARGE EXCHANGE ON NUCLEI. Grashin, A. F.; Shalamov, Ya. Ya. Yadern. Fiz., 9: 134-41(Jan. 1969). (In Russian).

Charge exchange $\pi^+$-scattering on nuclei of freon mixture and xenon was investigated in detail. The obtained experimental results may be explained on basis of the earlier proposed model of peripheral collisions with excitation of the recoil nucleus proceeding with small momentum transfer. The effect of the nuclear form factor is essential for the momentum transfer cut-off. (auth)

**18812** SINGLE $\pi^0$ MESON PRODUCTION IN THE INTERACTIONS $\pi^+$-Xe AT 2.34 GeV/c. Slovinski, B.; Strugalskii, Z. S. (Joint Inst. for Nuclear Research, Dubna, USSR). Yadern. Fiz., 9: 142-9(Jan. 1969). (In Russian).

Parameters of $\pi^0$ meson generated in the $\pi^+$-Xe interactions at 2.34 GeV/c are studied by means of a xenon bubble chamber. Some information on the $\gamma$-quanta spectra and on the effective mass $M_{\gamma\gamma}$ distribution is given. Values of transversal components of the $\pi^0$-meson momenta in stars with different numbers of prongs are given. (auth)

**18813** NATURE OF SECONDARY CHARGED PARTICLES GENERATED IN $\pi^-$-NUCLEI INTERACTIONS AT THE ENERGY OF 7 GeV. Assovskaya, A. S.; Ostroumov, V. I. (Ioffe Inst. of Physics and Tech., Leningrad). Yadern. Fiz., 9: 160-2(Jan. 1969). (In Russian).

An analysis is made of secondary particles produced at interactions of $\pi^-$ mesons with the momentum 7.2 GeV/c with emulsion nuclei. The fast particles were identified by means of measurements of relative ionization and of multiple Coulomb scattering. Relative yields of charged $\pi$ mesons, K mesons and protons were determined. (auth)

**18814** POLARIZATION OF $\Sigma^-$ IN THE REACTION $\pi^- + p \to \Sigma^- + K^+$ AT 1130 MeV/c. Edgington, J. A. (Queen Mary Coll., London); Howard, V. J.; Miller, M. C.; Ott, R. J.; Duke, P. J.; Hill, R. E.; Holley, W. R.; Jones, D. P.; Thresher, J. J.; Sleeman, J. C. Phys. Rev., 177: 2103-12(Jan. 25, 1969).

The polarization $P_{\Sigma^-}$ of the $\Sigma^-$ was measured in the production reaction $\pi^- + p \to \Sigma^- + K^+$ due to a $\pi^-$ beam of momentum 1130 MeV/c striking a polarized proton target. $P_{\Sigma^-}$ was found to lie between −0.1 and −0.5 in each of seven angular bins in the range $-1.0 < \cos\theta_{\Sigma^-} < 0.3$. Combining this and other measurements, an energy-dependent partial-wave analysis of the associated production reactions $\pi p \to \Sigma K$ was performed between threshold and 1170 MeV/c, using only S and P waves below 1130 MeV/c but including D waves at higher momenta. Using a momentum-dependent form for the amplitudes first proposed by Lee et al., the $I = 3/2$ amplitudes were found to be uniquely determined over the whole energy range, but the $I = 1/2$ amplitudes to have several solutions of similar, but low, likelihood. Thus, this particular parametrization does not appear to hold for the $I = 1/2$ channels near threshold. A possible reason is the presence of a highly inelastic $P_{11}$ resonance in the direct channel. (auth)

**18815** $K^-p$ INTERACTIONS FROM 594 TO 820 MeV/c. Bertanza, L. (Univ., Pisa, Italy. Istituto Nazionale di Fisica Nucleare, Pisa, Italy); Bigi, A.; Carrara, R.; (and others). Phys. Rev., 177: 2036-47(Jan. 25, 1969).

$K^-p$ interactions in the Columbia-BNL 30-in. hydrogen bubble chamber were studied at nine momenta from 594 to 820 MeV/c. The results for elastic-scattering and zero-prong-plus-$V^0$ events are presented here. Differential cross sections are given for the $K^-p$, $\overline{K}^0n$, and $\Lambda\pi^0$ final states. A fit to the $\overline{K}N$ channels was obtained which shows the effects of a $3/2^-$ resonance at 1701 MeV. This energy is appreciably displaced from the peak in the inelastic cross section. (auth)

**18816** STUDY OF NEUTRAL FINAL STATES PRODUCED IN $\pi^-p$ COLLISIONS AT MOMENTA OF 1.71 TO 2.46 GeV/c. Carroll, A. S. (Rutherford High Energy Lab., Chilton, Eng.); Corbett, I. F.; Damerell, C. J. S.; Middlemas, N.; Newton, D.; Clegg, A. B.; Williams, W. S. C. Phys. Rev., 177: 2047-66 (Jan. 25, 1969).

Neutral final states produced in $\pi^-p$ collisions at momenta of 1.71, 1.89, 2.07, 2.27, and 2.46 GeV/c were studied, by observing the $\gamma$ rays emitted. In particular, measurements are presented of (i) $\pi^-p \to \pi^0n$, for which the Regge-pole fit at momenta ≥ 5.9 GeV/c also agrees rather well here; (ii) $\pi^-p \to \eta^0n$, for which the Regge model which fits at higher energies does not agree here; (iii) $\pi^-p \to \pi^0\gamma n$, in which there is some evidence for a diffraction dissociation process as well as $\omega^0$-meson production; (iv) $\pi^-p \to \pi^0\pi^0n$, which is dominated by production of $N^{*0}(1236)\pi^0$ and by peripheral production of pion pairs. In (iv), the former process is found to fit with the same Reggeized $\rho$-meson exchange model as charge-exchange scattering, while the latter gives indication of the s-wave $\pi\pi$ interaction. An account is given of new techniques, particularly in the data analysis, which were developed in the course of this work. (auth)

**18817** PRODUCTION OF $\Sigma^\pm$ MULTIBODY FINAL STATES IN 5.5-GeV/c $K^-p$ INTERACTIONS. Kruse, U. E.; Loos, J. S.; Goldwasser, E. L. (Univ. of Illinois, Urbana). Phys. Rev., 177: 1951-65(Jan. 25, 1969).

Experimental results are presented for the reactions $K^-p \to \Sigma^+\pi^-\pi^0$ (1), $K^-p \to \Sigma^-\pi^+\pi^0$ (2), $K^-p \to \Sigma^\pm\pi^+\pi^+\pi^-$ (3) and (4), $K^-p \to \Sigma^\pm\pi^\mp K^+K^-$ (5) and (6), and $K^-p \to \Sigma^\pm\pi^\mp\pi^+\pi^-\pi^0$ (7) and (8). The data were obtained in a hydrogen bubble chamber exposed to 5.5-GeV/c incident $K^-$ mesons. This report is based on the analysis of a $K^-$

track length equivalent to 0.27 μb per event. Cross sections for (1)–(8) are presented. Reaction (1) is used to study the $\Sigma^+\rho^-(770)$ channel, and the results are compared to a Regge-model prediction made by Arnold. Reactions (2)–(8) are used to compile cross sections and production cosine distributions for ($Y_J^*$ + neutral meson) channels. Quasi-three-body production is observed in reactions (3), (4), and (7) for the channels $Y_J^*(1405)\pi^+\pi^-$, $Y_J^*(1520)\pi^+\pi^-$, $\Sigma^+\pi^+\rho^0(770)$, and $\Sigma^+\pi^-\omega^0(783)$. The production properties of the quasi-three-body final states suggest the presence of multiperipheral mechanisms. In reactions (7) and (8), a search was made for the $\delta^+(960)$ meson, with inconclusive results. (auth)

**18818** RESULTS FROM 3.0-GeV/c $K^+$ INTERACTIONS IN HYDROGEN. Dodd, W. P.; Joldersma, T.; Palmer, R. B.; Samios, N. P. (Brookhaven National Lab., Upton, N. Y.). Phys. Rev., 177: 1991-2002(Jan. 25, 1969).

The interaction of 3.0-GeV/c $K^+$ mesons on protons was studied in an exposure of the Brookhaven National Laboratory (BNL) 80-in. hydrogen bubble chamber at the alternating gradient synchrotron (AGS). Results are presented concerning a search for resonances requiring higher SU(3) representations than 8 or 10, namely, an isotopic-spin-1 ($K^+K^+$) or $-\frac{3}{2}$ ($K^+\pi^+$) boson, and an isotopic-spin-0 or −1 ($K^+n$) baryon. Evidence is also given for the existence of the N*(1400) resonance, as well as a new ($K\pi$) resonance with mass 1260 ± 20 MeV and width 70 MeV. (auth)

**18819** DOUBLE REGGE DESCRIPTION OF ω PRODUCTION IN $K^+p$ INTERACTIONS. Alexander, G.; Firestone, A.; Fu, C.; Goldhaver, G.; Pignotti, A. (Univ. of California, Berkeley). Phys. Rev., 177: 2092-2102(Jan. 25, 1969).

Results are presented on the ω and φ production in $K^+p \to K^+\omega p$ and $K^+p \to K^+\varphi p$ interactions at incident momenta of 4.6 and 9.0 GeV/c. There is no statistically significant evidence for Kω or Kφ resonance production. The 437 $K^+\omega p$ events at 9 GeV/c are analyzed in terms of a multiperipheral Regge model on the entire Dalitz plot. The events have been assigned to the various peripheral diagrams on the basis of criteria in the four-momentum transfers. A satisfactory description of the data has been obtained on the basis of diagrams involving Pomeranchuk and meson exchanges. (auth)

**18820** SEARCH FOR ($\Sigma^-$n) AND ($\Sigma^-$nn) BOUND STATES. Burnstein, R. A.; Cummings, W. C.; Swanson, D. L.; Veirs, V. R. (Illinois Inst. of Tech., Chicago). Phys. Rev., 177: 1945-50 (Jan. 25, 1969).

In an experiment involving $K^-$ capture in helium, a search was made for ($\Sigma^-$n) and ($\Sigma^-$nn) bound states as produced by the following reactions: $K^- + {}^4He \to (\Sigma^-n) + \pi^+ + d$; $K^- + {}^4He \to (\Sigma^-nn) + \pi^+ + p$. No unambiguous examples of these reactions were found among the interactions of 8370 stopping $K^-$ mesons. Upper limits on the rates for the production of these bound hyperon states are determined, relative to various $K^-$ capture reactions. With respect to stopping $K^-$ mesons, an upper limit on the bound-state production rate is ≤0.02%, using one ambiguous bound-state event for calculational purposes. In addition, for these data, no evidence was found for a maximally strong ($\Sigma^-$n) final-state interaction. (auth)

**18821** CROSS SECTIONS FOR $\Lambda^0$ PRODUCTION BY $\pi^-$ INTERACTIONS IN NUCLEI. Frankel, S.; Highland, V.; Sloan, T.; Van Dyck, O.; Wales, W. (Univ. of Pennsylvania, Philadelphia). Phys. Rev., 177: 2113-17(Jan. 25, 1969).

The total cross sections for $\Lambda^0$ production by 925-MeV $\pi^-$ mesons in Be, C, Al, Cu, and W were measured. The data suggest a simple production model with cross sections for medium-to-heavy nuclei varying as $(Z/A)A^{\frac{1}{3}}$. For Be, the energy dependence of the $\Lambda^0$ yield has been obtained in the region 750 to 1100 MeV. (auth)

## Particle Interactions and Properties (Theoretical)

*Refer also to abstract 18452.*

### General

**18822** (AD-673507) THEORY OF MANY BODY PROBLEM AND PARTICLE PHYSICS. Final Scientific Report, November 1, 1965-October 31, 1967. Brout, R.; Englert, F.; DeDominicis, C. (Brussels Univ. (Belgium). Faculte des Sciences). Jan. 1968. 13p. (AFOSR-68-1741). CFSTI.

A theoretical investigation was carried out in two areas: (a) Elementary particle theory along the lines of bootstrap theory, axial vector renormalization, Gell-Mann Okubo mass formula and PCAC, possible spontaneous breakdown of SU3, current algebra and partial symmetry. (b) Application of many body theory to theory of ferroelectricity, fluctuation driven spin waves, and the Onsager reaction field and molecular field theory. (auth) (USGRDR)

**18823** (CONF-671217–, pp 370-588) ELEMENTARY-PARTICLE PHYSICS: THEORIES. (Department of Atomic Energy, Bombay (India). Cosmic Ray Committee).

A review is given of elementary particle physics theories over the past two years. CP violation, SU(3) symmetry, SU(6) symmetry and its relativistic generalizations and S-matrix dynamics are discussed. Also discussed are current algebra and soft pion physics, high energy phenomenology and Regge poles, and sum rules. (J.F.P.)

**18824** SINGLE-PARTICLE INTERPRETATION OF THE DIRAC EQUATION WITHIN AN INFINITE SET OF PICTURES. Hanus, W.; Janyszek, H.; Rakowski, A. (Nicholas Copernicus Univ., Torun, Poland). Acta Phys. Pol., 34: 1071-86(Dec. 1968).

An infinite group of unitary transformations comprehending an "intermediary" domain between the two limiting cases of the Foldy–Wouthuysen and Cini–Touschek transformations was investigated with a view of obtaining some new conclusions concerning the one-particle interpretation of the Dirac equation from properties of the infinite set of pictures generated by this group of transformations. In particular, the role of a doubly-infinite set of generalized "mean" operators was discussed. (auth)

**18825** AN AMATEUR'S VIEW OF PARTICLE PHYSICS. Weisskopf, Victor F. (Massachusetts Inst. of Tech., Cambridge). Comments Nucl. Particle Phys., 3: 1-12(Jan.-Feb. 1969).

Impressions on the present state of particle physics are given. The baryon and meson excited states, quarks, electron scattering, current algebra, strong interactions, and CP violation are covered. (J.F.P.)

**18826** Z = 0 LIMITS IN THE LEE MODEL. Nagy, K. L. (Roland Eoetvoes Univ., Budapest). Acta Phys. Acad. Sci. Hung., 25: 227-8(1968).

In the Lee model where the vertex function remains unrenormalized and Z = 0 is considered as a sole condition, a situation is pointed out where Z = 0 can be arranged without changing the elementary V-particle into a composite one. (J.F.P.)

**18827** COVARIANT SPIN OPERATORS AND TRANSFORMATIONS. King, M.; Feldman, G. (Johns Hopkins Univ., Baltimore). Nuovo Cim., 60A: 86-100(Mar. 1, 1969).

The spin component of a particle can be specified in any of three independent directions. Covariant operators corresponding to three such choices are described, along with the transformations between their eigenstates. The usefulness of choosing a covariant description is demonstrated by considering the crossing matrices for helicity and transversity amplitudes as transformations between sets of such operators. Because of the covariance of the spin operators, arbitrary Lorentz transformations on the spin states introduce no complications such as the usual spin-rotation matrices. Although the discussion is limited to scattering processes of the type A + B → C + D, similar operators can be defined for systems of more than two particles. (auth)

**18828** MANY-BODY PROBLEM IN TERMS OF PARTICLE GROUP FUNCTIONS. Buetl, Gy. Acta Phys. Acad. Sci. Hung., 25: 177-96(1968).

In the treatment of many-particle systems the particle correlations can be taken into account to a certain extent at the very beginning by choosing particle-group basis functions. However, when these basis functions do not satisfy a certain restrictive condition ("strong orthogonality") some mathematical difficulties arise. Using a previously discovered way of overcoming these difficulties practical methods are developed to solve this problem. The Green's function formalism of Martin and Schwinger is applied using field operators for the particle groups with intrinsic degrees of freedom. Besides the possible computational advantages and the intrinsic interest of the problem this theory yields some possibilities for an ab initio microscopic theory of condensed media. In addition, it can also be useful in throwing light on some questions of relativistic field theory of structured particles. (auth)

**18829** ON THE CONSTRUCTION OF CURRENTS AND IRREDUCIBLE TENSORS OPERATING IN THE SPACE OF ONE-PARTICLE RELATIVISTIC STATES. Goldberg, Haim (Tel-Aviv Univ., Israel). pp 381-6 of Spectroscopic and Group Theoretical Methods in Physics. Block, F. (ed.). New York, John Wiley and Sons, Inc., 1968.

The space of operators which transform one-particle states into one-particle states is considered, and an attempt is made to construct currents and other operators with prescribed transformation properties. The case is considered where the two particles are identical, with mass m and spin $\sigma$; the procedure is applicable—with modifications—to cases of different masses and spins. (L.B.S.)

**18830** USE OF THE MONTE-CARLO-METHOD IN THE INVESTIGATION OF ELEMENTARY PARTICLE INTERACTIONS. Suranyi, Gyoergy. KFKI (Kozp. Fiz. Kut. Intez.) Kozlem., 16: 417-23(1968). (In Hungarian).

A FORTRAN program is described which generates interactions of elementary particles of given types by use of the Monte-Carlo-method. The simulated events can be used for the evaluation of the distributions of different quantities involved in physical experiments. (auth)

**18831** SEMINAR DE FIZICA TEORETICA. I. (Seminar in Theoretical Physics. I.). Novacu, V. (ed.). Bucharest, Editura Academiei Republicii Socialiste Romania, 1968. 372p.

Seven papers presented at the Seminar of Theoretical Physics are included. The first three papers on the theory of solids include quantum theory and transport coefficients, pseudopotential method in solid state physics, and integration functional and its application in polarization problems. The next group of four papers cover the theory of elementary particles including the theory and application of Lorentz group of nonhomogeneity, symmetry dynamics, theory of perturbation and dispersion and quark models and their application in high-energy physics. (R.V.J.)

**18832** NEW METHOD FOR THE RELATIVE MEASUREMENT OF $\beta$-RADIATION HELICITY. Braicovich, L. (Politecnico, Milan. CNR, Milan). Nuovo Cim., Lett., 1: 340-2(Feb. 21, 1969).

A new method is suggested for the relative measurement of $\beta$-radiation helicity, which is in many cases more powerful than the conventional ones. The basis of the method is provided by the dependence of the energy loss straggling suffered by a longitudinally polarized electron beam and of the target electrons. A monochromator having resolving power of some percent is used in order to obtain a $\beta$-ray beam which is slowed down in a magnetized foil; during slowing down the straggling process takes place so that a characteristic tail in the energy loss distribution is obtained and the intensity of this tail is measured with a second lens or with some other spectrometer. Since the intensity F of this tail depends on the relative polarization of the beam and of the target electrons, the beam polarization may be obtained from the measurement of the counting rate asymmetry $\delta = 2(F_p - F_a)/(F_p + F_a)$, where $F_p$ and $F_a$ are the tail intensities in the case of parallel and antiparallel polarizations. The method suggested is extremely powerful since the intensity of the tail which is detected is of the order of (2 ÷ 3)% of the whole intensity of the beam incident on the analyzer foil. (C.E.S.)

**18833** CONNECTION BETWEEN BOUND STATES OR RESONANCES OF TWO-PARTICLE AND THREE-PARTICLE SYSTEMS. Brayshaw, D. D. (Rockefeller Univ., New York. Brookhaven National Lab., Upton, N. Y.); Peierls, Ronald F. Phys. Rev., 177: 2539-55(Jan. 25, 1969).

The connection between three-particle resonances or bound states and the two-particle resonances or bound states of their component pairs is examined. A simpler and more general derivation is given of the Lovelace equations for isobar or bound-state scattering. As an example, a one-dimensional model of a system of three identical particles, each pair of which interacts only through a single bound or resonant state of energy $\nu_0$, is constructed, and the corresponding off-shell scattering integral equation is obtained. By examining the analytic structure as a function of the off-shell momentum at fixed energy, an expression is obtained for the off-shell scattering amplitude involving explicitly known functions and the solution of a much less singular equation. When $\nu_0$ is the position of a resonance pole of the two-particle system, the three-particle denominator function has a pole at an energy $4\nu_0$ on the unphysical sheet where denominator zeros are associated with resonances, provided that the two-body resonance has a smooth form factor. This suggests the presence of a three-body resonance in this neighborhood if the two-body resonance is narrow. That is not true for bound states. The relation of this to the expected behavior of more realistic problems is discussed. (auth)

**18834** KHURI–TREIMAN-TYPE EQUATIONS FOR THREE-BODY DECAY AND PRODUCTION PROCESSES. II. Pasquier, R. (Institut de Physique Nucleaire, Saclay, France); Pasquier, J. Y. Phys. Rev., 177: 2482-93(Jan. 25, 1969).

The complications arising from the introduction of nonzero angular momenta in a dispersion model for three-body decay or production are discussed in a definite example, based essentially on the elastic approximation in each subenergy channel. First production or decay amplitudes free from kinematical singularities are defined. Then it is shown that a convenient choice of these amplitudes leads to integral equations to which the conclusions found in an earlier work in the zero-angular-momentum case apply for the most part, especially as regards three-body unitarity. Further details are given in the case of a three-pion final state. (auth)

**18835** PHASE-BAND ANALYSIS: A TOOL FOR PARTICLE REACTIONS AT HIGH ENERGIES. Moravcsik, Michael J. (Univ. of Oregon, Eugene). Phys. Rev., 177: 2587-90(Jan. 25, 1969).

A modification of the traditional phase-shift analysis is suggested which is aimed at greatly reducing the number of parameters needed for the phenomenological description, and thereby making it possible to analyze a complete set of scattering data at energies which previously would have proven impractically high. Although devised with elementary-particle physics in mind, the new method might also find applications in nuclear physics. (auth)

**18836** DISPERSIVE APPROACH TO CURRENT ALGEBRA. Gervais, J.-L. (New York Univ., N. Y.). Phys. Rev., 177: 2182-98(Jan. 25, 1969).

The current-algebra scheme, not including equal-time commutators of two space components, is formulated entirely in terms of covariant dispersion relations (i.e., over the laboratory energy for fixed mass) where the number of subtractions is chosen according to the usual Regge picture. To do this, one expresses the equal-time commutators and retarded commutators directly in terms of the covariant dispersion integrals, using an identity between covariant and noncovariant dispersion integrals of Lorentz-invariant distributions which is proved here, by means of the Jost-Lehmann representation, from the locality of the currents. This last result is a generalization of previous works of Schroer and Stichel and of Le Bellac and the author. In the scheme discussed here, the equal-time commutators and retarded commutators are rigorously defined as a consequence of the physical high-energy behavior, contrary to the usual approach where they are only formally written as product of the commutator with $\delta(x_0)$ and $\theta(x_0)$, respectively. In fact, it is shown that the properties usually derived formally (as, e.g., by partial integration) are rigorously true in our scheme. The quantities which in the usual approach are not well defined, and/or are model-dependent—such as the Schwinger term, the seagull term, and the equal-time commutator of the current and the divergence—are given in this approach by the subtraction constants of the dispersion relations introduced. They are shown to exhibit the properties which usually are more or less assumed, or only obtained in models; e.g., it is proved that the divergence of the seagull term is equal to the Schwinger term. Only matrix elements averaged over spin and/or relative momenta, with the vacuum matrix element subtracted, are considered. No explicit value of the equal-time commutator is assumed at the beginning, so as to clearly show the respective roles of the internal symmetry group and of the analyticity and high-energy behavior. A previous work of the author on the infinite-momentum limit based on the same approach is also completed. (auth)

## *Electromagnetic*

*Refer also to abstracts 18460, 18867, 18880, 18883, 18916, 18927, and 18970.*

**18837** (AD-673841) SPIN-RELATED POLARIZATION EFFECT IN COMPTON SCATTERING OF RELATIVISTIC ELECTRONS. Lu, Ching-fa. Translated from Wu Li Hsueh Pao, 21: 1927-31(1965). 9p. (FTD-HT-67-394). CFSTI.

In the production of high energy photons from Compton scattering of particles by relativistic electrons, the inclusion of particle spin may significantly increase the scattering cross section and the degree of polarization. The effect of various possible spin states on Compton scattering by relativistic electrons is studied. The equation of differential cross section can be written according to the transition probability of particles. In the case of charged particles with longitudinal spin (spin parallel to direction of motion), an equation of energy distribution for secondary photons is derived. Calculation shows that the scattering cross section for the production of polarized high energy photons may be twice as large for particles with directional spin as for spinless particles. In the case of charged particles with transverse spin (spin perpendicular to direction of motion), the higher order approximations disappear in the relativistic case. Using a final state summation procedure, the scattering

cross section equation for transverse spin charged particles can be easily reduced to the common Klein-Nishina formula for stationary electrons. Affected by the transverse spin, the scattered photons become partially or completely polarized despite the nonpolarization of the primary photons. (auth) (USGRDR)

**18838** (BNL-tr-249) REMARKS ON ELECTROMAGNETIC INTERACTIONS OF $K^0_{1,S}$ MESONS. Lapidus, L. I. (Joint Inst. for Nuclear Research, Dubna (USSR)). Translated by Stephen J. Amoretty (Brookhaven National Lab., Upton, N. Y.). From report JINR-P2-4047. 6p. Dep. CFSTI.

The $K^0_2 \rightarrow K^0_1$ regeneration on electrons and the possibility of observing various effects associated with the electromagnetic interactions of the $K^0_2$, $K^0_1$ mesons are considered. The possibility of observing the effects of electromagnetic regeneration as a result of the study of asymmetry in the leptonic decay behind the plate is discussed. Also discussed is the small effect of the CP violation in the superposition of $K^0_2$ and $K^0_1$ on the electromagnetic regeneration of $K^0_2$, $K^0_1$ mesons and on the pair production process of $K^0 - \overline{K^0}$ in electron–positron collisions. (J.F.P.)

**18839** (ISS-68/33) ALGEBRA OF CURRENTS. [PART] II. Maiani, L.; Preparata, G. (Istituto Superiore di Sanita, Rome (Italy). Laboratori di Fisica). Oct. 1, 1968. 58p. Dep.

A review of current algebra is given. This review includes low-energy theorems from current algebra covering the covariant method, rederivation of the Adler–Weisberger relation, soft-pion emission, meson (K) decays, and the $\eta$ decay. Also the Weinberg sum rules are discussed including derivation of the sum rules, and the $\pi^+ - \pi^0$ mass difference. Current algebra at small distances is discussed. This discussion covers electron and neutrino sum rules, the Bjorken method, electromagnetic mass shifts, radiative corrections to weak interactions, and the cut-off problem of the weak interactions. (J.F.P.)

**18840** (ITF-68-49) REMARK ON THE $\eta \rightarrow 3\pi$ DECAY. Struminskii, B. V. (Akademiya Nauk Ukrainskoi SSR, Kiev. Institut Teoreticheskoi Fiziki). 1968. 7p. (In Russian). (CONF-680647-3). Dep.

From Conference on Composite Models of Elementary Particles, Kiev, USSR.

The decay rate $\eta \rightarrow 3\pi$ is calculated. The calculations are based on the pole model of the $\eta \rightarrow 3\pi$ decay. The matrix element of the $\eta \rightarrow \pi$ transition is calculated using the finite energy sum rules for the virtual compton-scattering amplitude. (TSS)

**18841** ELECTROMAGNETIC FORM FACTOR. Truong, Tran N. (Institut des Hautes Etudes Scientifiques, Bures-sur-Yvette, France); Mau, R. Vinh; Yem, Pham Xuan. New Phys. (S. Korea), Suppl., 7: No. 2, 56-8(June 1968).

A systematic study of the pion electromagnetic form factor is given. The root mean square radius of the pion is expressed, and it is considered of great interest to measure the time-like pion form factor in the low-energy region for a comparison. (J.F.P.)

**18842** HARMONIC ANALYSIS ON THE DALITZ PLOT. Lee, Benjamin W. (State Univ. of New York, Stony Brook). New Phys. (S. Korea), Suppl., 7: No. 2, 41-9(June 1968).

Expansion of 3-pion wave functions and 3-pion decay amplitudes in terms of a complete set of orthonormal functions on the Dalitz plot is discussed. A new coordinate system $(\alpha,\beta)$ is proposed which is more convenient than the polar coordinates $(\rho,\theta)$ for this purpose. The desired harmonics $\lambda^n_m(\alpha,\beta)$ are then characterized as products of a polynomial in $\alpha$, and a trigonometric function of $\beta$. It is noted that I, $I_z$ and (m,n) completely characterize the $J = 0$, $3\pi$ system. The representation of the S-matrix in this orthogonal basis is considered, and the low Q-value behavior of the S-matrix elements and decay amplitudes in this representation is discussed. The connection between the harmonics constructed and the SU(3) classification of (nonrelativistic) three particle systems proposed by Dragt is established. The extension of the present method for higher J follows from this observation. (auth)

**18843** THEORY OF COMPTON SCATTERING OF POLARIZED PHOTONS ON POLARIZED PARTICLES WITH SPIN ½. Kukanov, A. B.; Amer, A. A. (Moscow State Univ.). Izv. Vyssh. Ucheb. Zaved., Fiz., No. 8, 121-8(1968). (In Russian).

Formulas were obtained for the effective differential scattering cross section for elliptically polarized photons incident on polarized point Dirac particles initially at rest and possessing charge and an anomalous magnetic moment. Cases in which the incident photon was nonpolarized, linearly polarized, and circularly polarized were analyzed. (tr-auth)

**18844** PHOTON ABSORPTION IN NUCLEI AND VECTOR-MESON DOMINANCE. Nauenberg, Michael (Univ. of California, Santa Cruz). Phys. Rev. Lett., 22: 556-8(Mar. 17, 1969).

It is shown that in some applications of vector-meson dominance to photon reactions in nuclei the mass of the $\rho$ meson cannot be neglected at photon energies of current interest. Thus, in calculation of the photon absorption cross section in the optical-model approximation, the effect of the $\rho$ mass $m_\rho$ is important for photon energies $\omega \lesssim m_\rho^2(R/\sigma N)^{1/2}$, where R and N are the radius and density of the nucleus, and $\sigma$ is the total $\rho$-nucleon cross section. (auth)

**18845** ON THE LOW–BURNETT–KROLL THEOREM FOR SOFT-PHOTON EMISSION. Bell, J. S.; Van Royen, R. (CERN, Geneva). Nuovo Cim., 60A: 62-8(Mar. 1, 1969).

Burnett and Kroll's extension of Low's theorem is proved for particles of arbitrary spin. (auth)

**18846** A PCAC PUZZLE: $\pi^0 \rightarrow \gamma\gamma$ IN THE $\sigma$-MODEL. Bell, J. S. (CERN, Geneva); Jackiw, R. Nuovo Cim., 60A: 47-61 (Mar. 1, 1969).

The effective coupling constant for $\pi^0 \rightarrow \gamma\gamma$ should vanish for zero pion mass in theories with PCAC and gauge invariance. It does not so vanish in an explicit perturbation calculation in the $\sigma$-model. The resolution of the puzzle is effected by a modification of Pauli-Villars-Gupta regularization which respects both PCAC and gauge invariance. (auth)

**18847** PRODUCTION OF ELECTRON-POSITRON PAIRS UPON THE COLLISION OF A SINGLE PHOTON WITH A PLANE ELECTROMAGNETIC WAVE. Ternov, I. M.; Bagrov, V. G.; Klimenko, Yu. I.; Kholomai, B. V. (Moscow State Univ.). Izv. Vyssh. Ucheb. Zaved., Fiz., No. 8, 71-5(1968). (In Russian).

The production of electron-positron and boson pairs upon the collision of a single photon with an intense circularly polarized plane wave was examined. Polarization and spin effects were studied. (TSS)

**18848** BASES DE L'ELECTRONIQUE QUANTIQUE. TOME 2. ABSORPTION ET EMISSION DE CHAMP ELECTROMAGNETIQUE. (Fundamentals of Quantum Electronics. Volume 2. Absorption and Emission of Electromagnetic Field). Bertein, Francois. Paris, Editions Eyrolles, 1969. 601p. 190 F.

The properties of matter in the presence of electromagnetic fields are examined. A description mode in some dynamic sort of the effect of a perturbation is first studied. Some elements of quantum statistical mechanics are given, particularly concerning the equilibrium states and the relaxation phenomena. The behavior of a given sample with respect to the electromagnetic field is then considered. The phenomena of magnetic resonance are also studied. The most important properties and methods of study are given. The applications themselves are examined only in their essential characteristics. (tr-auth)

**18849** ELECTROMAGNETIC RADIUS OF THE PION. Khalfin, L. A.; Shcherbin, Yu. P. (Steklov Mathematics Inst., Leningrad). JETP Lett. (USSR) (Engl. Transl.), 8: 397-400(Dec. 5, 1968).

Translated from Zh. Eksp. Teor. Fiz., Pis'ma Redaktisyu, 8: 642-5(Dec. 5, 1968).

A modification of previous dispersion relations is used to determine numerically the meson ($\pi$) electromagnetic radius. In this modification the contribution from the near-threshold region in the first integral is suppressed as a result of the factor $(t' - t^0)$, and the region of the $\rho$ resonance becomes very important for the calculation of this integral. (J.F.P.)

**18850** EVALUATION OF THE PHOTOPRODUCTION OF NEGATIVE PIONS ON NEUTRONS IN THE REGION OF THE FIRST RESONANCE. Schwela, D. (Univ., Bonn). Z. Phys., 221: 158-74(1969).

A systematic investigation of pion photoproduction is extended to the case of negative pion production on neutrons. In our approach two phenomenological parameters occur in the electric and magnetic dipole amplitudes $E_{0+}$ and $M_{1-}$. These constants have been determined by a least squares fit of the total cross section data of the ABBHHM collaboration. A very good fit is obtained, and the prediction of the asymmetry ratio for polarized photons agrees with experiment at energies below and at the resonance. Serious discrepancies between theory and experiment are found for the $\pi^-/\pi^+$ ratio, moreover the relationship between the electric dipole at threshold, the Panofsky ratio and the difference of s-wave $\pi$N-scattering lengths is fulfilled only within 20%. These discrepancies are discussed thoroughly. (auth)

**18851** ELECTROMAGNETIC MASS DIFFERENCE FOR K MESONS. Zinov'ev, G. M.; Struminskii, B. V. (Joint Inst. for Nuclear Research, Dubna, USSR). Yadern. Fiz., 9: 173-5(Jan. 1969). (In Russian).

K-meson electromagnetic mass difference is calculated using finite-energy sum rules for the virtual Compton-scattering amplitude. The results are in good agreement with experiment. (auth)

**18852** A REGGE-CUT MODEL FOR $\pi^0$ PHOTOPRODUCTION. Capella, A.; Tran Thanh Van, J. (Laboratoire de Physique Theorique et Hautes Energies, Orsay, France). Nuovo Cim., Lett., 1: 321-7(Feb. 21, 1969).

A simple explanation for previous results on pion photoproduction in a large range of energy and momentum transfer is presented, and some predictions for the values of R at higher energies are given. The model is based on the exchange of the $\omega$ trajectory plus a Regge cut due to the exchange of $\omega$ and P. (J.F.P.)

**18853** CURRENT COMMUTATORS AND ELECTRON SCATTERING AT HIGH MOMENTUM TRANSFER. Cornwall, John M. (Univ. of California, Los Angeles); Norton, Richard E. Phys. Rev., 177: 2584-6(Jan. 25, 1969).

Sum rules for electron-proton total cross sections are deduced from the vanishing of various equal-time commutators, and it is shown how these cross sections determine the (spin-averaged) proton expectation values of all equal-time commutators involving components of the electric current and their time derivatives. Mild restrictions on the asymptotic behavior of electromagnetic form factors are also obtained. (auth)

**18854** SELF-CONSISTENT CALCULATION OF THE $\rho$-MESON ELECTROMAGNETIC MASS SPLITTING. Cohen, S. L. (Univ. of Oregon, Eugene). Phys. Rev., 177: 2556-61(Jan. 25, 1969).

Under the assumption that the electromagnetic (E.M.) mass splittings within the pseudoscalar and vector-meson octets self-consistently generate each other (at least in part), the $\rho^\pm - \rho^0$ mass difference in terms of the vector-pseudoscalar-pseudoscalar (VPP) coupling strength $g^2/4\pi$ and the vector-vector-pseudoscalar (VVP) coupling strength $h^2/4\pi$. The requirement that $g^2$ and $h^2$ be in reasonable agreement with experiment strongly favors a small absolute value for $M_{\rho^\pm} - M_{\rho^0}$, with a negative value not ruled out. (auth)

**18855** CURRENT ALGEBRA, DISPERSION RELATIONS, AND THE $\rho^+$-$\rho^0$ MASS DIFFERENCE. Vaishya, J. S. (National Physical Lab., New Delhi. Univ. of Delhi). Phys. Rev., 177: 2512-14(Jan. 25, 1969).

An analysis of the $\rho^+$-$\rho^0$ mass difference has been made using (a) on-mass-shell current algebra, and (b) dispersion theory. The former method gives a logarithmically divergent result similar to the one obtained by the phenomenological Lagrangian approach. In dispersion theory, if unsubtracted dispersion relations are written for the form factors describing virtual-photon-$\rho$-meson scattering, then the mass difference is quadratically divergent. However, once-subtracted dispersion relations with the subtraction constant taken from current algebra, together with the assumption of $\rho$ dominance of the dispersion integrals, gives a result similar to that obtained from (a). (auth)

**18856** BOUNDS ON THE PION ELECTROMAGNETIC FORM FACTOR. Truong, Tran N. (Institut des Hautes Etudes Scientifiques, Bures-sur-Yvette, France); Vinh-Mau, R. Phys. Rev., 177: 2494-2500(Jan. 25, 1969).

Upper and lower bounds for the spacelike pion form factor are given in terms of a dispersion integral of the modulus of its timelike form factor. Similar bounds are obtained for its phase (in the timelike region) which in turn provide information on the low-energy P-wave pion-pion scattering. The upper and lower bounds approach the same limit, and hence become equalities, if the zeros of the form factor are far from the physical region of interest. (auth)

**18857** SUPERCONVERGENCE AND ASYMPTOTIC BEHAVIOR OF NUCLEON FORM FACTORS. Moffat, J. W. (Univ. of Toronto). Phys. Rev., 177: 2456-7(Jan. 25, 1969).

The superconvergence of the dispersion relation for the nucleon isovector form factor is discussed in relation to $\rho$ dominance and the contributions due to the process $N + \bar{N} \to \pi + \pi$. Certain predictions are made about the pion form factor in the timelike region which are consistent with the colliding-beam experiment at Novosibirsk. (auth)

**18858** REGGE PARAMETRIZATION OF PHOTOPRODUCTION PROCESSES. I. Cooper, Fred (Harvard Univ., Cambridge, Mass.). Phys. Rev., 177: 2398-2416(Jan. 25, 1969).

In the first of a series of articles on photoproduction processes, the formulas for all the observables for $\pi$- and K-meson photoproduction processes are written in terms of the Regge parameters for the trajectories that can be exchanged in the t channel. Special consideration is given to the simplification of these formulas when polarized photon beams are used and special choices of the polarization angle are chosen. All the conspiracy relations and kinematic factors are taken into account. (auth)

**18859** ELECTROMAGNETIC MASS DIFFERENCES AND SUM RULES IN A LAGRANGIAN MODEL. Auvil, P. R.; Deshpande, N. G. (Northwestern Univ., Evanston, Ill.). Phys. Rev., 177: 2345-9(Jan. 25, 1969).

The canonical commutation rules of the Brown-Munczek Lagrangian are found and other equal-time commutators of the theory are evaluated. The fields do not obey a chiral SU(2) algebra exactly; it is in the time components of the axial-vector field where the algebra fails. These commutators are related to the pion electromagnetic mass difference and to sum-rule calculations. Using the Bjorken criteria, it is concluded that the mass-difference calculation diverges in general, but in the tree-diagram approximation the coefficient of the logarithmic divergence vanishes. This result is analyzed in detail and compared with other models. In particular, even in this model in the tree approximation, the $\rho$-mass calculation diverges. The spectral sum rules of the algebra are seen to be equivalent to those due to Weinberg and lead to the same successful predictions if the partially conserved axial-vector current and Kawarabayashi-Suzuki-Fayyazuddin-Riazuddin relations are included in the model. It is also possible to construct an axial-vector current which obeys the chiral algebra of charges. (auth)

**18860** ON-SHELL $K^+$-$K^0$ ELECTROMAGNETIC MASS DIFFERENCE. Chaudhuri, R. N.; Bondyopadhyay, D. (Univ. of Delhi). Phys. Rev., 177: 2342-5(Jan. 25, 1969).

The on-shell electromagnetic mass difference of kaons is studied using the four-point-function identities developed by Gerstein and Schnitzer. The mass difference, which is logarithmically divergent, remains so even in the soft-kaon limit because of the inapplicability of Weinberg's generalized second sum rule. It is shown that the correct sign of the $K^+$-$K^0$ mass difference can be obtained at sufficiently high cutoff even without using the $\sigma$-term. (auth)

**18861** FOUR-POINT FUNCTION AND $\rho' \to 2\pi\gamma$ DECAY. Chaudhuri, R. N.; Dutt, Ranabir (Univ. of Delhi). Phys. Rev., 177: 2337-41(Jan. 25, 1969).

Radiative decay of the $\rho$ meson was studied within the framework of the four-point function of currents obeying SU(2) $\otimes$ SU(2) chiral algebra. A hard-pion calculation of the decay amplitude by means of the four-point function shows the correct gauge-invariant electromagnetic structure of the radiative process, while the same amplitude evaluated in the off-shell limits $q^2 \to 0$, $p^2 \to 0$ for the pions fails to account for the dominant dynamical features, such as the internal bremsstrahlung mechanism and gauge invariance. A comparative study of both on-shell and off-shell current-algebra predictions for decay rates and the photon energy spectrum have been presented, along with the results of the vector-meson pole-dominance model. (auth)

**18862** MINIMAL CURRENT ALGEBRA. Bjorken, J. D. (Stanford Univ., Calif.); Brandt, R. A. Phys. Rev., 177: 2331-6(Jan. 25, 1969).

An algebra of currents and their first time derivatives designed to damp at high momentum the asymptotic behavior of lepton-pair scattering amplitudes from hadrons consequent from the local current algebra of Gell-Mann are devised. Given certain criteria, the algebra found is unique, and the commutators are expressed linearly in terms of the currents themselves. The Jacobi identity, however, is formally violated for this algebra; it is argued that this does not invalidate it. A possible realization of this "minimal" algebra is found in terms of the formal limit of a massive Yang-Mills theory as $g_0, m_0 \to 0$; $g_0/m_0^2 \to$ const $\neq 0$. With this algebra, all electromagnetic masses of hadrons are finite. Experimental consequences, the strongest of which occurs in inelastic lepton-hadron scattering, are outlined. (auth)

**18863** ELECTROMAGNETIC MASS DIFFERENCES, EQUAL-TIME COMMUTATORS, AND OSCILLATING SPECTRAL FUNCTIONS. Brandt, Richard A.; Sucher, Joseph (Univ. of Maryland, College Park). Phys. Rev., 177: 2218-38(Jan. 25, 1969).

Motivated by its implication of a divergent pion electromagnetic mass shift $\delta m^2$, some aspects of the Bjorken limit relating the high-$q_0$ behavior of the amplitude $T(q;p) = -i\int dx\, e^{-iq\cdot x} \langle p|T(J(x)J'(0))|p\rangle$ to the equal-time commutators $[\delta_0^0 J, J']$ are studied. The aim is to find ways to avoid an infinite $\delta m^2$ without altering the usual current-current commutation-relation models which have $[J, J'] \neq 0$. It is noted that, contrary to what is usually assumed, perturbation-theoretic T products rarely vanish at high $q_0$. It is rigorously shown that when $T(q;0)$ is the pion-photon scattering amplitude at $p = 0$ and admits a spectral representation $\int da\, \sigma(a)(q^2 + a)^{-1}$ (including an arbitrary number of subtractions and an arbitrary additive polynomial), the corresponding mass shift $\delta m_3^2$ can be finite only if the moment $I = \int da\, \sigma(a)$ is either zero or does not exist; in the latter case, $\sigma(a)$ must change sign infinitely often in any neighborhood of $a = +\infty$. The nonexistence

of I corresponds to the presence of ambiguities in the commutator $[\dot{J},J']$, although, as is emphasized, the commutator can be given a consistent nonvanishing value with $\delta m_J^2$ remaining finite. As an interesting example of this possibility, the function $T(q;0) = \exp[-(q^2)^{1/2}]$ is considered, which gives $\delta m_J^2 < \infty$ and I undefined, but which can correspond to any value of $[\dot{J},J']$, provided that the equal-time limit is taken in a suitable way. It is argued that such an exponential falloff for the forward photohadron scattering amplitude M is a likely consequence of an exponentially falling nucleon electromagnetic form factor, a behavior which is consistent with experiment and a number of theoretical ideas. Additional support for such behavior for M comes from the observation that this type of behavior might be expected to hold in theories with asymptotic (on-shell) hadronic scattering amplitudes of the form, e.g., $\exp[-(-t)^{1/2}]$, and the considerable theoretical and experimental evidence in favor of such behavior is reviewed. Finally, the extension of our analysis to the case where $p \neq 0$ and Schwinger terms are present is discussed. In particular, an exponential falloff for $T(q;p)$ implies an oscillating spectral function and strongly suggests that I is undefined. Some purely mathematical results concerning the existence of spectral representations when no explicit assumption is made about the asymptotic behavior of the spectral function are also obtained; these may be useful in other contexts. (auth)

**18864** SPECTRAL FUNCTION OF THE PHOTON PROPAGATOR: MASS SPECTRUM AND TIMELIKE FORM FACTORS OF PARTICLES. Terazawa, Hidezumi (Tokyo Univ.). Phys. Rev., 177: 2159-66(Jan. 25, 1969).

The contributions to the spectral function of the photon propagator from the states which contain a particle (charge e and mass $m_J$) of arbitrary spin J, and its antiparticle are considered. The contributions in terms of timelike form factors $F_J(a)$ (where $a = -^2p > 0$, and P is the momentum of the photon) with the normalization $F_J(0) = (2J + 1)e^2$. The unitarity limit of the spectral function can be transformed into the asymptotically bounded condition $F_J(a) \lesssim O(a)$. The experimental information about the anomalous magnetic moment of the muon gives a restriction on the sum of all the contributions. Using the restriction, various mass spectra of charged particles are examined and simple results are obtained. For example: If there is an infinitely rising mass spectrum $m_J = f(J)$, then the asymptotic form of the mass formula must be bounded by condition $m_J > O(J)$ (case I or II) or $m_J > O(J^{1/(2l+1)})$ (case III), where l is a parameter in the form factors, assumed to be $F_J(a) = (2J + 1)e^2(a/4m^2 - 1)|1 - a/\mu^2|^{-2l}$ for $J = 0, 1, 2, \ldots$, and $F_J(a) = (2J + 1)e^2|1 - a/\mu^2|^{-2l}$ for $J = \frac{1}{2}, \frac{3}{2}, \ldots$. For the purpose of experimental observations of the timelike form factors and the spectral function of the photon, the colliding-beam experiments $e^+ + e^-$ (or $\mu^+ + \mu^-$) $\rightarrow \lambda + \bar{\lambda}$ (where $\lambda$ is a particle of arbitrary spin) are discussed in some detail. (auth)

**18865** MASS SPLITTINGS AND GHOST TADPOLES. Ball, J. S. (Univ. of California, Los Angeles); Zachariasen, F. Contract AT(11-1)-68. Phys. Rev., 177: 2264-72(Jan. 25, 1969).

The neutron-proton mass difference is expressed, on the assumption that it is purely electromagnetic in origin, in terms of partial-wave amplitudes for the process $N\bar{N} \rightarrow \gamma\gamma$ at zero total energy, and also in terms of the single $n = 0$, $M = 0$ O(4) amplitude for the same process. This representation allows quite directly a qualitative understanding of the sign of the n-p mass difference, and also allows, with more drastic assumptions, an approximate numerical evaluation of the mass difference based on experimentally determined parameters from the $A_2$ Regge trajectory. This numerical estimate is in reasonable agreement with experiment. The approach is easily generalized to other electromagnetic mass differences, and is shown to yield the tadpole model. (auth)

## Weak

*Refer also to abstracts 18775, 18839, 18842, 18880, and 18947.*

**18866** (ISS-68/32) ALGEBRA OF CURRENTS. [PART] I. Maiani, L.; Preparata, G. (Istituto Superiore di Sanita, Rome (Italy). Laboratori di Fisica). Oct. 1, 1968. 61p. Dep.

A review of current algebra is presented. Currents and their physical relevance including CVC, SU(3) algebra of vector currents, PCAC, the SU(3) ⊗ SU(3) chiral algebra, and models of current algebras including current algebra in the quark model, Schwinger terms, the algebra of quark charges, the algebra of fields, the $p \rightarrow \infty$ method, and behavior of the currents in the $p \rightarrow \infty$ limit are covered. Also covered are the physical consequences of the algebra of charges including the Ademollo–Gatto theorem, the Adler–Weisberger relation, and resonance saturation of the SU(3) ⊗ SU(3) algebra of charges, and tests of local algebras including the local chiral algebra, the Cabibbo–Radicati sum rule, the Creil–Hearn sum rule, and the axial dipoles sum rule. (J.F.P.)

**18867** (ISS-68/35) DYNAMICAL INTERRELATION OF WEAK, ELECTROMAGNETIC, AND STRONG INTERACTIONS AND THE VALUE OF $\theta$. Cabibbo, N.; Maiani, L. (Istituto Superiore di Sanita, Rome (Italy). Laboratori di Fisica). Oct. 16, 1968. 13p. Dep.

A new approach to hadron dynamics is described which includes the combined effects of weak and electromagnetic interactions. Symmetry breakings in the strong Hamiltonian are determined by weak and electromagnetic forces in a self consistent way. The effects of weak corrections, computed at second order with a cutoff $\Lambda$ ($G\Lambda^2 \approx 1$) coincide with those computed to all orders in a model with a neutral vector boson. A one-parameter family of solutions is found, depending on $\theta$, and comparison with the observed breaking parameters leads to $\sin\theta \approx 0.22$. (auth)

**18868** WEAK ELECTRON SCATTERING: $e^- + p \rightarrow \Lambda + \nu$. Fearing, H. W. (CERN, Geneva); McNamee, P. C.; Oakes, R. J. Nuovo Cim., 60A: 10-24(Mar. 1, 1969).

It is emphasized that intense, monochromatic electron beams from superconducting accelerators may make it possible to study certain electron-induced weak-interaction processes. In particular the process $e^- + p \rightarrow \Lambda + \nu$ is analyzed. After a review of a number of familiar points which can be examined via this reaction, i.e. (i) time-reversal invariance, (ii) the Cabibbo hypothesis, (iii) partial conservation of the strangeness-changing axial vector current (PCAC), numerical estimates are given for the total and differential cross sections and for possible time-reversal violating terms, based on simple models. (auth)

**18869** HADRONIC DECAYS OF THE INTERMEDIATE W BOSON. Ershov, D. K. (Smolensk State Pedagogical Inst., USSR). Izv. Vyssh. Ucheb. Zaved., Fiz., No. 8, 116-20(1968). (In Russian).

The decays of the W boson ($W \rightarrow \bar{N} + N^*$, $W \rightarrow \bar{N}f + Nf$, where $N^*$ and N are particles with spin $\frac{3}{2}$ and $\frac{1}{2}$) were studied with assumptions concerning the form of the current of the generated particle. Expressions for the total and differential decay probabilities were derived. (tr-auth)

**18870** MECHANISM OF GENERATION OF ULTRAHIGH-ENERGY MUONS WITH NEARLY ISOTROPIC AZIMUTHAL DISTRIBUTION BY COSMIC RAYS. Shabalin, E. P. JETP Lett. (USSR) (Engl. Transl.), 8: 395-7(Dec. 5, 1968).

Translated from Zh. Eksp. Teor. Fiz., Pis'ma Redaktsiyu, 8: 639-41(Dec. 5, 1968).

It is pointed out that a mechanism, whereby mesons ($\mu$) can be produced in the upper layer of the atmosphere, is contained in a natural fashion in the theory of renormalizable weak interactions. This theory was developed earlier and explains the experimental observation of mesons ($\mu$) from cosmic rays with energy $E > 10^3$ GeV. (J.F.P.)

**18871** LEADING WEAK DIVERGENCES, COMPOUND FIELD ALGEBRA, AND CABIBBO ANGLE. Gatto, R.; Sartori, G.; Tonin, M. (Univ., Padua. Istituto Nazionale di Fisica Nucleare, Padua). Nuovo Cim., Lett., 1: 399-403(Mar. 11, 1969).

A proof of the following theorem is given. The theorem states that the leading divergences in the self-masses are renormalized to all orders by a counterterm, a fixed superposition of $u_0$, $u_3$, $u_8$, $u_8$, and $u_1$, in any model in which the currents obey the algebra of compound fields, which is the limiting case of the algebra of fields for compound gauge mesons. Convergence conditions are equivalent to requiring the vanishing of the coefficients in front of $u_3$ and $u_8$ in the superposition. The following result is also obtained. This theorem states that the same counterterm introduced in the former theorem is sufficient to guarantee that the weak vertex, after inclusion of all (leading divergent) weak radiative corrections, preserves its universal form $(J_1 + iJ_2)\cos\theta + (J_4 + iJ_5)\sin\theta$ assuming the validity of the algebra of compound fields. (J.F.P.)

**18872** NEUTRINOS. Brandt, Siegmund (Univ. of Heidelberg). Bild Wiss., 5: 674-83(Aug. 1968). (In German).

Classical and recent studies of neutrinos are reviewed. The postulations of Pauli are related in context of the need for conservation of various physical parameters. The experiments of Wu and her colleagues in 1957 demonstrating the failure to conserve parity in the decomposition of $^{60}Co$ are reviewed from the standpoint of establishing the antineutrino. Studies of the decompositions of muons which led to the discovery of the neutrinos associated with muons are outlined. Descriptions of these experiments using the accelerators at Brookhaven and CERN are detailed. Further experiments with neutrinos to study weak interactions are discussed, and the possibility of using neutrinos for problems in astrophysics is noted, particularly for the study

of the interiors of stars. Speculations about the detection of neutrinos released in the primary event of the universe are raised, particularly since the excess number of neutrinos produced then is anticipated to be large. (BBB)

**18873** MUON CAPTURE AND THE HYPOTHESIS OF PARTIALLY CONSERVED AXIAL-VECTOR CURRENT. Frazier, J.; Kim, C. W. (Johns Hopkins Univ., Baltimore). Phys. Rev., 177: 2568-73(Jan. 25, 1969).

The results of a new calculation of the muon-capture rates in hydrogen and $^3$He are presented, with special emphasis on the estimate of the induced pseudoscalar form factor $F_P$. Two values of $F_P$ based on the Nambu and the Gell-Mann-Lévy versions of the PCAC hypothesis are given, and the corresponding capture rates are compared with experimental data. (auth)

**18874** POLE DOMINANCE AND A LOW-ENERGY THEOREM IN THE RADIATIVE DECAYS OF CHARGED KAONS. Rockmore, Ronald (Internationational Centre for Theoretical Physics, Trieste, Italy). Phys. Rev., 177: 2573-8(Jan. 25, 1969).

A low-energy theorem is derived for the structure-dependent axial-vector form factor in the radiative decay $K \to l + \nu + \gamma$ in the soft-kaon approximation. Corrections of the order of $(m_{K^2}/m_{V^2})$ (V = $\rho$, $\omega$, $\varphi$) are obtained in the pole-dominance approximation. In each approximation, the model predictions of both (i) asymptotic SU(3) and (ii) current mixing are investigated. The quantity $|\gamma_K| \equiv |\alpha_K(0)/F(0)|$ is calculated in both approximations and in both models. It is found that the soft-kaon result is shifted upward by approximately 20%; the separation between the models in the two approximations is of the same order of magnitude. (auth)

**18875** ISOTROPY IN $\pi$-$\mu$ DECAYS. Frota-Pessoa, E. (Istituto Nazionale Fisica Nucleaire, Trieste, Italy). Phys. Rev., 177: 2368-70(Jan. 25, 2969).

An extensive analysis is made of all results on the angular distribution of $\pi$-$\mu$ decays in the nuclear-emulsion stack used by Hulubei et al. Instead of the conclusion of their previous analyses, which favored anisotropy for this distribution, it is shown that there is some lack of agreement between the several experiments using plates from this stack. The results of two experiments, which seems to be the safe part of scanning of this stack, are in good agreement with isotropy. (auth)

**18876** INEQUALITIES FOR THE $K_{l3}$ FORM FACTORS. Horn, D. (Argonne National Lab., Ill. Tel-Aviv Univ., Israel). Phys. Rev., 177: 2272-3(Jan. 25, 1969).

An inequality for the $K_{l3}$ form factors is derived on the basis of current commutation relations and certain assumptions about the relative importance of the intermediate states. It includes the inequalities due to Quinn and Bjorken and to Suzuki. It is found that $\xi \leq 0.91/f_+(0) - 1.35$, where $\xi = f_-(0)/f_+(0)$ and $f_+(0) \leq 1$. (auth)

## *Strong (General)*

*Refer also to abstracts 18867, 18930, 19004, and 19017.*

**18877** (ITF-68-36) FORMATION OF NEUTRAL VECTOR MESONS DURING HADRON INTERACTION. Rekalo, M. P. (Akademiya Nauk Ukrainskoi SSR, Kiev. Institut Teoreticheskoi Fiziki). 1968. 20p. (In Russian). (CONF-680453-20). Dep.

From 2nd Conference on Axiomatical Field Theory and Theory of Elementary Particles, Kiev, USSR.

The formation of low-energy neutral vector mesons in the reactions $\gamma + N \to N + V^0$, $\pi + N \to N + V$, $\bar{p} + p \to V_1^0 + V_2^0$, $K^- + p \to Y + V$, $\pi^\pm + p \to \pi^\pm + p + V^0$, $p + p \to p + p + \omega$ is considered in the quark model. The near-threshold behavior of these processes can be explained in a model based on the quark-nuclear analogy: the emission of $\gamma$-quanta by a nuclear system and the emission of neutral vector mesons by a quark system generated due to hadron collisions are considered to be quite similar. In this model the vector mesons of electric monopole type with J = 0 and positive parity should be created near the threshold in an overwhelming way. Then the isotropic angular distribution is predicted for the reaction $K^- + p \to \gamma + V^0$, $\pi^- + p \to n + V^0$ the angle dependence of the type $\sin^2\theta$ is predicted for the processes $\gamma + p \to p + V^0$ while the S-state annihilation is forbidden for the processes $\bar{p} + p \to V_1^0 + V_2^0$. The relations between cross sections of various reactions generating vector mesons, predicted by the model in question are in good agreement with experiment. (auth)

**18878** (ITF-68-45) STRONG COUPLING, CALCULATION OF BOUND STATES. Simenog, I. V. (Akademiya Nauk Ukrainskoi SSR, Kiev. Institut Teoreticheskoi Fiziki). 1968. 15p. (In Russian). Dep.

The physical characteristics of bound states of the two-body problem are studied depending on the coupling constant g (and large g). The problem of bound states of systems with a small number of nucleons is considered. (auth)

**18879** (ITF-68-48) THE EFFECT OF THE RELATIVISTIC QUARK MOTION IN MESONIC DECAYS. Struminskii, B. V. (Akademiya Nauk Ukrainskoi SSR, Kiev. Institut Teoreticheskoi Fiziki). 1968. 7p. (In Russian). (CONF-680647-4). Dep.

From Conference on Composite Models of Elementary Particles, Kiev, USSR.

The well-known Kawarabayashi-Suzuki relation $g_{\rho\pi\gamma} = f_\pi m_\rho$ is obtained using the quasi-independent quark model which takes into account the relativistic effects. (auth)

**18880** (NP-17766(Pt.3)) INTRODUCTION TO THE PHYSICS OF THE ELEMENTARY PARTICLES. III. FUNDAMENTAL PROPERTIES OF THE PARTICLES AND OF THEIR INTERACTIONS. Gerber, H. J. (Geneva Univ. (Switzerland). Laboratoire de Physique Nucleaire Experimentale). [1967]. 71p. (In French). Dep.

The magnitudes and constants characterizing elementary particles and interactions are derived. The classification of particles, classification of interactions, description of reactions by fundamental interactions, and excited states of particles or resonances are considered. (J.S.R.)

**18881** DUALITY DIAGRAMS. Harari, Haim (Weizmann Inst. of Science, Rehovoth, Israel). Contract F-61052-68-C-0070. Phys. Rev. Lett., 22: 562-5(Mar. 17, 1969).

The duality between the s- and t-channel descriptions of strong-interaction scattering amplitudes and the assumption that in every channel the scattering proceeds via nonexotic resonances are exhibited by simple diagrams. The diagrams lead to simple derivations of some known consequences of these assumptions as well as to many new predictions which can be tested experimentally. (auth)

**18882** REGGE BEHAVIOR, RESONANCES, AND CROSSING. Fubini, Sergio (Massachusetts Inst. of Tech., Cambridge). Comments Nucl. Particle Phys., 3: 22-7(Jan.-Feb. 1969).

A short survey is given of problems in Regge behavior, resonances, and crossing. It is concluded that strong interaction physics has greatly improved from the Regge pole theory of the early sixties. (J.F.P.)

**18883** HADRON MASSES IN THE QUARK MODEL. Rubinstein, H. R. (Weizmann Inst. of Science, Rehovoth, Israel); Talmi, I. pp 301-15 of Spectroscopic and Group Theoretical Methods in Physics. Block, F. (ed.). New York, John Wiley and Sons, Inc., 1968.

A detailed analysis is presented of the masses of the best known particles. The quark model used is a theory in which nonrelativistic quantum mechanics is applied to a system of real or mathematical quarks for the study of effects which can be considered as perturbations. The wave functions of the baryons are constructed and the mass splittings are calculated. The connection between these results and the group theoretical mass formulas is briefly discussed. The masses of pseudoscalar and vector mesons are then discussed. (L.B.S.)

**18884** LOW-ENERGY THEOREM FROM PAIR SUPPRESSION AND SOME APPLICATIONS. Ishida, Shin; Roman, P. (Boston Univ.). Phys. Rev., 177: 2371-4(Jan. 25, 1969).

Assuming separate conservation of quark and antiquark number in the static limit, a general theorem on the low-energy limit of scattering amplitudes of hadron processes is derived. Numerous applications of this theorem are made. A slight modification of the procedure leads also to predictions on pion-pion scattering lengths. (auth)

**18885** INTERACTION OF TWO BOSONS AND TWO FERMIONS IN THE KEMMER-DUFFIN THEORY. Ainsaar, A. Tr. Inst. Fiz. Astron., Akad. Nauk Est. SSR, No. 33, 60-7(1967). (In Russian).

A general consideration of the boson current separate from the cases of spin 0 and 1 is developed. The correlation between formfactors in the Kemmer-Duffin and the Klein-Gordon formulations is shown. The law of conservation of the vector current is investigated. It is deduced that there are no principal differences between the boson currents in the Kemmer-Duffin and the Klein-Gordon theories. (auth)

## *Strong (Baryon No. = 0)*

*Refer also to abstracts 18842, 18909, and 18916.*

**18886** NEW LINKS BETWEEN REGGE-POLE THEORY AND CURRENT ALGEBRA. Weinberg, Steven (Massachusetts Inst.

of Tech., Cambridge). Comments Nucl. Particle Phys., 3: 28-35 (Jan.-Feb. 1969).

A review of the connections between Regge pole theory and current algebra is given including a first step taken by Lovelace in adapting the Veneziano model to the fundamental process of pion–pion scattering. Also discussed is the result that when two trajectories of opposite normality can be connected by strong single-pion emission their slopes must be equal, and their residues must differ by half odd integers. (J.F.P.)

**18887** DECAY $1^+ \rightarrow 1^- + 0^-$. Bolsun, A. I. (Inst. of Physics, Minsk). Dokl. Akad. Nauk BSSR, 11: 685-7(Aug. 1967). (In Russian).

Within the framework of SU(3) symmetry the decay $1_8^+ \rightarrow 1_8^- + 0_8^-$ was studied where the $1^+$ mesons include the octet E(1420), $A_1$(1080), and $K_A$(1320). From the matrix element for the decay $1_8^+ \rightarrow 1_8^- + 0_8^-$, invariant with respect to the SU(3) group and the operation of charge conjugation, the relations between the coupling constants for the various decays were obtained. The matrix element of the $1^+ \rightarrow 1^- + 0^-$ decay was calculated in the $\beta$ formalism and depends only on one constant. The ratios between the probabilities for the various decays were also obtained. (tr-auth)

**18888** VENEZIANO FORMULA AND $A_1\rho\pi$ SYSTEM. Fayyazuddin; Riazuddin (Univ. of Islamabad, Rawalpindi, Pakistan). Phys. Lett., 28B: 561-3(Feb. 3, 1969).

Applying the Veneziano formula to the process $\pi^+\pi^- \rightarrow \pi^- A_1^+$ the Weinberg mass relation for the $A_1$ meson is derived by using the Adler's self consistency condition. It is also shown that $G_S/G_D \approx -m_\rho^2$, where $G_S$ and $G_D$ determine s and d-wave decay of $A_1 \rightarrow \rho\pi$. The ratio favors $\delta$ (anomalous magnetic moment of $A_1$) $\approx -1$. (auth)

**18889** HIGHER MULTIPLETS OF MESON AND BARYON RESONANCES. A CONSEQUENCE OF RESONANCE SATURATION HYPOTHESIS. Roy, D. P.; Suzuki, M. (CERN, Geneva). Phys. Lett., 28B: 558-60(Feb. 3, 1969).

Meson resonances with exotic quantum numbers, predicted by Rosner under the assumption of local resonance saturation, are shown to follow from the much less stringent assumption of global resonance saturation. The same hypothesis, applied to the scattering of baryons against these mesons, is then shown to imply the existence of baryon resonances with exotic quantum numbers as well. And the latter, in turn, seems to imply meson resonances, with still more exotic quantum numbers. (auth)

**18890** ANALOGY OF THE KAWARABAYASHI–SUZUKI RELATION FOR THE VECTOR MESONS OF THE ISOSINGLETS. Bolewski, J. (Univ., Warsaw). Bull. Acad. Pol. Sci., Ser. Sci. Math. Astron. Phys., 16: 899-904(1968).

Some methods leading to the extension of the so called Kawarabayashi–Suzuki relation for vector mesons of the isotopic singlets, that is, for the particles $\phi$ and $\omega$, are presented. It is concluded that the relation found is in good agreement with the present experimental data and it seems to be a new success of current algebra and PCAC as applied to pseudoscalar mesons other than pions and the method of soft kaons. (J.F.P.)

**18891** FIT TO S-WAVE $\pi\pi$ PHASE-SHIFTS USING CURRENT ALGEBRA. Neveu, A.; Scherk, J. (Faculte des Sciences, Orsay, France). Nuovo Cim., Lett., 1: 414-19(Mar. 11, 1969).

It is shown that by slightly improving a previous parameterization a much better one-parameter fit is obtained to the last compilation of S-wave phase shifts, the results of which seem to indicate the existence of a broad resonance at about 700 MeV. Thus one reconciles the Weinberg scattering length with the existence of large phase shifts at moderate energies. (J.F.P.)

**18892** POSITIVITY CONDITIONS FOR VENEZIANO FORMULAE. Oehme, R. (Univ. of Chicago). Nuovo Cim., Lett., 1: 420-3(Mar. 11, 1969).

Some preliminary results are presented concerning the question of the positivity of residua for elastic amplitudes. It is found that in the case of $\pi\pi$ scattering all individual Veneziano terms, with the possible exception of the lowest one, have an infinite number of negative residua. (J.F.P.)

**18893** COMMENTS ON THE VENEZIANO MODEL. Fujisaki, H. (Tokyo Univ.). Nuovo Cim., Lett., 1: 396-8(Mar. 11, 1969).

It is shown that in the reaction $\pi\pi \rightarrow \pi\omega$ the Veneziano amplitude satisfies the conditions that higher resonances on linear trajectories should have vanishing elasticities and/or total decay widths larger than spacings. There is no inconsistency concerning the polynomial boundedness in s for the scattering amplitude. (J.F.P.)

**18894** MODIFIED EXTRAPOLATION TO DETERMINE THE $\pi\pi$ CROSS SECTION. Kane, G. L.; Ross, Marc (Univ. of Michigan, Ann Arbor). Phys. Rev., 177: 2353-7(Jan. 25, 1969).

The dependence of the $\pi + N \rightarrow (2\pi) + N$ cross section for low invariant $\pi\pi$ mass and small $|t|$ is discussed with a view toward extrapolation to the pion pole and extraction of $\pi\pi$ phase shifts. There is a complicated t-dependent term in the cross section which makes extrapolation inaccurate. This term can be isolated by consideration of certain moments (in the distribution with respect to the pion angles $\theta$, $\varphi$ in the dipion rest frame), if nucleon helicity flip is assumed to dominate. Indirect empirical evidence and the absorption model with $\pi$ exchange both support this assumption in the 5–10-BeV/c region. The assumption is weaker than the popular assumption that the Chew–Low pion-exchange formula holds, and can also be directly tested by examining the t dependence of certain moments at 0° (forward production of the dipion). For s- and p-wave $\pi\pi$ scattering, one considers the coefficients of 1, $\cos\theta$, and $\sin^2\theta$ in addition to the usual $\varphi$-dependent terms. The coefficient of $\sin^2\theta$ is the complicated term. It is reasonable to hope that the remaining moments are smoothly varying for $0 \geq -t \gtrsim 4\mu^2$, and are suitable for extrapolation. They are constrained to a definite t dependence at 0° by angular momentum conservation. It is believed that reliable determination of the $\pi\pi$ cross section in the $\rho$ region and below is attainable by this method in high-statistics experiments currently under way. (auth)

**18895** INFINITELY RISING REGGE TRAJECTORIES AND CROSSING SYMMETRY. Atkinson, D. (Rutherford High Energy Lab., Chilton, Eng.); Dietz, K. Phys. Rev., 177: 2579-81 (Jan. 25, 1969).

It is found that, in a crossing-symmetric model of a scattering amplitude A(s,t) which is dominated by Regge-pole exchange, the restrictions imposed by analyticity on the Regge trajectory $\alpha(s)$ and by analyticity and polynomial boundedness in s for fixed t on A(s,t), suggest uniquely the asymptotic behavior $\alpha(s) \sim s/\ln s$ as $s \rightarrow \infty$, if the large-s and large-t limits of $\ln A(s,t)$ are uniform. The use of a double-dispersion relation for $\ln A(s,t)$ is proposed. (auth)

**18896** $\rho$ BOOTSTRAP IN THE UNITARIZED STRIP APPROXIMATION. Collins, P. D. B.; Johnson, R. C. (Univ. of Durham, Durham City, Eng.). Phys. Rev., 177: 2472-81(Jan. 25, 1969).

A method is presented of improving the new strip approximation of Chew and Jones by calculating parts of the elastic double spectral functions using the Mandelstam iteration procedure. These double spectral functions are used to obtain additional contributions to the left-hand cuts of the partial-wave amplitudes, and also to estimate the inelasticity within the strip region. The inelastic N/D equations are solved in the way proposed by Frye and Warnock. The method is applied to the problem of bootstrapping the $\rho$ trajectory in $\pi$-$\pi$ scattering, and some preliminary results are presented. It is found that it is possible to obtain a self-consistent trajectory with the correct physical mass, width, and intercept $\alpha(0)$, but that the solution is by no means unique, since self-consistency can be achieved with trajectories having intercepts anywhere from $\alpha(0) = 1$ to $\alpha(0) \approx 0.2$. Also, the trajectories have a large curvature, and large residue, which result in a violation of crossed-channel unitarity for low l. (auth)

**18897** S-MATRIX CALCULATION OF PION–PION SCATTERING. Graves-Morris, P. R. (Univ. of Kent, Eng.). Phys. Rev., 177: 2285-7(Jan. 25, 1969).

A one-parameter model of the pion-pion scattering amplitude is given. Taylor series expansions of the three isospin amplitudes are used in the two formulations of the model, and crossing symmetry and unitarity are imposed to given order. The S-wave phase shifts in second order are calculated, and both agree qualitatively with the experimental results of Walker et al., in the 300 to 700-MeV range. (auth)

**18898** BROKEN-SYMMETRY SUM RULES FROM SUPERCONVERGENT DISPERSION RELATIONS. Fuchs, Norman H. (Purdue Univ., Lafayette, Ind.). Phys. Rev., 177: 2274-7 (Jan. 25, 1969).

Generalized superconvergent sum rules are derived for reactions of the type $P + P \rightarrow P + V$, where P and V are pseudoscalar and vector mesons, respectively. The sum rules are of such a form that a natural range exists, over which saturation by a limited number of resonances is appropriate and outside of which negligible contribution to the sum rules is made. Results include SU(6)-type relations such as $m_\rho^2 - m_\pi^2 = m_{K^*}^2 - m_K^2$, $m_\rho = m_\omega$. (auth)

**18899** EQUIVALENT-POTENTIAL APPROACH TO $\rho$-MESON BOOTSTRAP AND THE NARROW-WIDTH APPROXIMATION. Vaidya, S. M. (Tata Inst. of Fundamental Research, Bombay). Phys. Rev., 177: 2251-2(Jan. 25, 1969).

Various bootstrap calculations make use of the narrow-width approximation for the exchanged particles. Recently, using the

determinantal form for the N/D equations, Atkinson and Ong found that there is no self-consistent solution for the $\rho$-bootstrap problem in $\pi\pi$ scattering if one uses the more realistic Breit-Wigner form for the exchanged particles. The same problem is investigated in detail by using the method of an equivalent potential. It is found that the bootstrap solution is not lost and the value of the width obtained for $\rho$ with a Breit-Wigner form for the input is not widely different from the one obtained with a narrow-width approximation. A nice feature of this calculation is that the shape of the resonance curve for the output is in good agreement with that for the input. (auth)

## *Strong (Baryon No. = 1)*

*Refer also to abstracts 18465, 18889, 18890, 18894, and 18954.*

**18900** TEST OF REGGE PARAMETERS BY INVERSE DISPERSION RELATIONS. Hoehler, G.; Ebel, G. (Univ., Karlsruhe, Ger.). New Phys. (S. Korea), Suppl., 7: No. 2, 21-2 (June 1968).

The inverse dispersion relation for the helicity flip amplitude $B^{(+)}$ leads to a consistency condition for the P and P' residues which agrees with Gatto's sum rule for the Pomeranchuk residuum. The condition is violated by one of the solutions for the residue proposed by Chiu, Rarita and Phillips. (auth)

**18901** BARYON STATE OF MATTER UP TO THE $\pi$-MESON PHASE. Shishkin, G. V. (Inst. of Nuclear Engineering, Minsk). Dokl. Akad. Nauk BSSR, 11: 692-5(Aug. 1967). (In Russian).

Within the framework of the model of superdense degenerate gas of elementary particles, the threshold baryon densities of all the known baryon states that appear in the stellar nucleus up to its entrance into the $\pi$-meson phase of its evolution are calculated. In the succession of baryon states there are first created the negatively charged baryons, then the neutral, and finally the positively charged baryon states. The $\pi$ mesons are stabilized for baryon densities of $\sim 10^{41}$ cm$^{-3}$. (tr-auth)

**18902** A METHOD FOR INCLUDING RESONANCE PRODUCTION IN A REGGEIZED MULTIPERIPHERAL MODEL. Plahte, E.; Roberts, R. G. (CERN, Geneva). Nuovo Cim., 60A: 33-46(Mar. 1, 1969).

The phenomenological model of Chan et al. is generalized to include the formation of resonances between particles of low invariant mass. As well as removing an inconsistency of the model, resonance production successfully accounts for the pronounced backward peak in baryon longitudinal-momentum distributions. The improved model has been applied to the reactions $\pi^+p \to p + (n-1)\pi$ at 8 GeV and $K^-p \to \Lambda + (n-1)\pi$ at 6 GeV with n varying from 3 to 6. Good qualitative agreement with the experimental two-particle effective mass distributions is obtained. (auth)

**18903** MASS DIFFERENCES IN $J^P = \frac{1}{2}^+$ ISOMULTIPLET BARYONS. Zaks, M. B. (Saratov State Univ., USSR). Izv. Vyssh. Ucheb. Zaved., Fiz., No. 8, 100-5(1968). (In Russian).

The mass differences in $J^P = \frac{1}{2}^+$ isomultiplet baryons were calculated taking into account the contribution of weak interactions in the Reggeized tadpole models of Okubo and the broken isotopic symmetry of Lippman. (tr-auth)

**18904** MOMENTUM TRANSFER SPECTRUM IN DIFFRACTION DISSOCIATION. Oh, B. Y.; Walker, W. D. (Univ. of Wisconsin, Madison). Contract AT(11-1)-881. Phys. Lett., 28B: 564-6(Feb. 3, 1969). (COO-881-202).

The peculiar momentum transfer spectrum found for a diffraction dissociation process $\pi^- + p \to \pi^- + (\pi^+ + n)$ is shown to be easily understood in terms of the one pion exchange process. It is suggested that almost all of the $N^*(1400)$ phenomenon can be understood in this way (OPE). (auth)

**18905** CALCULATION OF PHASE SPACE INTEGRALS BY MONTE-CARLO-METHOD. Suranyi, Gyoergy. KFKI (Kozp. Fiz. Kut. Intez.) Kozlem., 16: 407-15(1968). (In Hungarian).

A program segment has been worked out for the evaluation of integrals over the phase space. The application of this segment permits one to evaluate cross sections and differential cross sections determined by a given matrix element. The description of the segment written in FORTRAN is given and some results obtained while checking the segment are reported. (auth)

**18906** THE $\pi$N PARTIAL WAVES AT LOW ENERGIES AND IN THE UNPHYSICAL REGION. Baacke, J.; Hoehler, G.; Steiner, F. (Univ., Karlsruhe, Ger.). Z. Phys., 221: 134-40 (1969).

The real parts of the $\pi$N partial wave amplitudes $f_{l\pm}^{(-)}$ were calculated from fixed-t dispersion relations, using phase shifts up to 2 GeV and the reggeized $\rho$-exchange model at higher energies. The comparison with Re $f_{l\pm}^{(-)}$ as calculated directly from phase shifts shows to what extent the input is consistent with the fixed-t relation. The result is also of interest for the test of simple models, in particular for the comparison with predictions from current algebra. A new evaluation of the partial wave dispersion relation for $f_{0+}^{(-)}$ is presented. Combined with the first method it shows that the determination of the $\rho$-coupling parameter is based on an assumption which is difficult to justify. (auth)

**18907** MODIFIED INTERFERENCE MODEL FOR $\pi N$ SCATTERING. Kohsaka, Y.; Miyamura, O.; Takagi, F.; Itabashi, K. (Tohoku Univ., Sendai). Nuovo Cim., Lett., 1: 408-13(Mar. 11, 1969).

On the basis of previous results, a possible modification of the conventional interference model is proposed which may be free from double counting. This model is applied to intermediate-energy $\pi + N$ scattering near the forward direction. (J.F.P.)

**18908** PARTIAL-WAVE ANALYSIS OF THE REGGE AMPLITUDES FOR $\pi N$ SCATTERING. Kohsaka, Y.; Miyamura, O.; Takagi, F.; Itabashi, K. (Tohoku Univ., Sendai). Nuovo Cim., Lett., 1: 404-7(Mar. 11, 1969).

Using a previous Regge pole model a partial-wave analysis if performed for $\pi N$ scattering and compared with the phase shifts reported previously. The results show good correspondences between Argand circles from the partial-wave projection of Regge-exchange amplitudes and the known resonances for $\sqrt{s} > 1.8$ GeV. The height of the Argand circles from Regge exchanges is found to be $\frac{1}{2}$ to $\frac{1}{3}$ of that of the existing resonances. Thus apparent double counting arises in the conventional interference model. The spin-parities of $\Delta(2420)$ and N(2650) may be $11^+/2$ and $11^-/2$ respectively, and there is a probable existence of $N_\alpha(9^+/2)$ and $N_\delta(7^+/2)$ resonances. Also $\Delta_\beta(9^-/2)$ and $N_\beta(9^-/2)$ are expected in the mass region around 2.2 GeV. (J.F.P.)

**18909** PARTICLE MASSES. Rafique, M.; Saleem, M. (Panjab Univ., Lahore). Nuovo Cim., Lett., 1: 331-2(Feb. 21, 1969).

Equations are given for calculating the masses of new particles. These masses are tabulated including only those particles and resonances which were established after Guggenheimer proposed his formula. (J.F.P.)

**18910** SUPERCONVERGENT RELATION FOR $\pi$,N $\to \pi D_{13}$ AND THE $\pi D_{13} D_{13}$ COUPLING CONSTANT. Ragusa, S. (Instituto de Fisica Teorica, Sao Paulo, Brazil). Nuovo Cim., Lett., 1: 328-30(Feb. 21, 1969).

The reaction $\pi^i(q_1) + N(p_1) \to \pi^j(q_2) + D_{13}(p_2)$ is considered. A realistic estimate of the $g_{DD\pi}$ coupling is found in so far as the inclusion of only low-lying intermediate states is accepted. (J.F.P.)

**18911** RESCATTERING MODEL FOR $K^- + p \to \Sigma^- + \pi^+$. Singh, C. P.; Agarwal, B. K. (Allahabad Univ., India). Phys. Rev., 177: 2350-2(Jan. 25, 1969).

A rescattering model is proposed which accounts for the experimental angular distributions in the process $K^- + p \to \Sigma^- + \pi^+$. (auth)

**18912** CHARGE-EXCHANGE SCATTERING DATA AND THE SCHMID HYPOTHESIS. Kreps, R. E.; Logan, R. K. (Univ. of Toronto). Phys. Rev., 177: 2328-30(Jan. 25, 1969).

The partial waves resulting from $\rho$, N, and $\Delta$ exchange in pion-nucleon charge-exchange scattering are compared with the experimental values obtained from phase-shift analyses between 1 and 2 GeV. The lack of correspondence adds to the doubt concerning the Schmid hypothesis and its criticism of the interference model. (auth)

**18913** RESONANCE PARAMETERS FOR LOW-ENERGY $\eta$n PRODUCTION. Deans, S. R. (Univ. of South Florida, Tampa). Phys. Rev., 177: 2623-4(Jan. 25, 1969).

A pole-resonance model for the process $\pi^-p \to \eta n$ is used to compute the low-energy $\eta n$ resonance parameters for ten isospin-$\frac{1}{2}$ nucleon resonances. (auth)

**18914** RESIDUE ZEROS FOR A PARITY-DEGENERATE $N_\alpha$ TRAJECTORY. James, P. B. (Univ. of Missouri, St. Louis). Phys. Rev., 177: 2625-6(Jan. 25, 1969).

It is shown that a parity-degenerate nucleon Regge trajectory is consistent with known constraints if and only if the residue function develops at least three zeros. The position of one of these zeros is such that the spin-$\frac{1}{2}^-$ N' state, expected at 939 MeV, is eliminated. (auth)

**18915** SUM RULES IN $\pi\Sigma$ SCATTERING AND THE $\pi\Lambda\Sigma$ AND $\pi\Sigma\Sigma$ COUPLING CONSTANTS. Everett, Allen E. (Tufts Univ., Medford, Mass.). Phys. Rev., 177: 2561-7(Jan. 25, 1969).

Following a procedure proposed recently by Atkinson, sum rules are derived for the A and B amplitudes for the reaction $\pi^- + \Sigma^+ \to \pi^+ + \Sigma^-$ by equating unsubtracted dispersion relations at t = 0 and

at fixed u or fixed backward angle. Combining these with the already known superconvergence relation for the B amplitude, and assuming the sum rules can be saturated with known resonances, three equations are obtained for two unknown couplings constants $g_{\pi\Lambda\Sigma^1}$ and $g_{\pi\Sigma\Sigma^1}$. Choosing to fix u = 0, values of the coupling constants are obtained with an order of magnitude larger than expected on the basis of, say, SU(3). It is argued that this is probably because of the large extrapolation to unphysical values of $\cos\theta$ required in evaluating the fixed-u dispersion relation for u = 0. Taking u to be positive in such a way as to minimize the required extrapolations in angle, or choosing fixed $\cos\theta = -1$, results are obtained that are reasonably consistent with one another and with SU(3), to within estimated uncertainties of 50% or more, resulting from experimental error in the resonance widths, large cancellations between the contributions of different resonances, and unknown nonresonant-background and high-energy contributions. (auth)

**18916** CHIRAL-SYMMETRIC MESON–NUCLEON LAGRANGIANS. Kramer, G. (Argonne National Lab., Ill.). Phys. Rev., 177: 2515-28(Jan. 25, 1969).

A phenomenological Lagrangian for a theory of nucleons and scalar, pseudoscalar, vector, and axial-vector mesons is constructed on the basis of linear representation of chiral SU(2) × SU(2). The Lagrangian for this extended $\sigma$ model is used for a study of strong interactions of the particles involved and for the derivation of threshold theorems for pion-nucleon and pion-pion scattering, photoproduction of pions on nucleons, and the production of an s-wave isoscalar resonance by pions on nucleons. (auth)

**18917** PION–NUCLEON SCATTERING LENGTHS. Dutta-Roy, Binayak; Lapidus, I. Richard; Tausner, Menasha J. (Stevens Inst. of Tech., Hoboken, N. J.). Phys. Rev., 177: 2529-30 (Jan. 25, 1969).

Pion-nucleon scattering lengths were calculated using a model in which N, N*, $\rho$, and $\epsilon$ exchanges are assumed to dominate the low-energy pion-nucleon interaction. This simple model yields remarkably good agreement with the experimental s- and p-wave scattering lengths. It is found that the coupling of the $\epsilon$ meson to the nucleon is consistent with estimates made using chiral symmetry and current algebra. (auth)

**18918** CUT CONSPIRACY AND PION EVALUATION IN $\pi^+$ AND $\pi^-$ PHOTOPRODUCTION. Froeyland, Jan; Gordon, David (Massachusetts Inst. of Tech., Cambridge). Contract AT(30-1)-2098. Phys. Rev., 177: 2500-4(Jan. 25, 1969).

A four-trajectory model to interpret $\pi^+$ and $\pi^-$ photoproduction off nucleons is proposed. The model makes use of evading $\pi$ and $\rho$ trajectories, an evading $\rho$P cut, and a conspiring $\pi$P cut. The model is found to be in good agreement with $\pi^+$ photoproduction data for lab $\gamma$-ray energies ranging from 2 to 16 GeV and $|t|$ values ranging from $10^{-4}$ to 2.0 $(GeV/c)^2$. It is also found to be in good agreement with the observed t-dependent ratio of $\pi^-$ to $\pi^+$ photoproduction at 3.4 and 5 GeV. Predictions are made for high-energy charged photo-meson production cross sections in which the bombarding photon is polarized. (auth)

**18919** UNITARITY, CURRENT ALGEBRA, AND s-WAVE $K^+p$ SCATTERING. Bhargava, S. C. (Univ. of Delhi). Phys. Rev., 177: 2205-9(Jan. 25, 1969).

Two procedures for unitarizing current-algebra results are studied and applied to the elastic $K^+p$ scattering amplitude. It is noted that if the current-algebra amplitude in the off-mass-shell limit is used as input, the unitarity correction leads to good agreement with experiments on phase shifts and other low-energy parameters. (auth)

**18920** BARYON EXCITATION FORM FACTORS AND ASYMPTOTIC CHIRAL SYMMETRY. Schechter, J. (Syracuse Univ., N. Y.); Ueda, Y. Phys. Rev., 177: 2300-8(Jan. 25, 1969).

An explicit multipole decomposition of the vector and pseudovector N-N*(1236) transition form factors is made, and the predictions of asymptotic chiral symmetry are discussed. A general consistency between the chiral predictions and the simplest assumptions on multipole behavior is found for one choice of decuplet chiral representation. (auth)

**18921** $K^+$-NUCLEON SCATTERING IN AN EFFECTIVE CHIRAL LAGRANGIAN MODEL. Schechter, J. (Syracuse Univ., N. Y.); Ueda, Y.; Venturi, G. Phys. Rev., 177: 2311-17 (Jan. 25, 1969).

The S-wave $K^+$-nucleon scattering lengths are calculated in a phenomenological chiral model containing baryons and pseudoscalar mesons. Good agreement with experiment is found, in contrast to the usual current-algebra results which correspond to unphysical limits of our expressions. The sensitivity of the calculation to various modifications of the Langrangian is also discussed. In particular, the scattering lengths are observed to be rather dependent on the way SU(3) symmetry breaking is introduced into the model. (auth)

**18922** PHENOMENOLOGICAL MULTICHANNEL $ND^{-1}$ ANALYSIS OF $\pi$N SCATTERING. Ball, James S. (Univ. of California, Los Angeles); Garg, Ramesh C.; Shaw, Gordon L. Phys. Rev., 177: 2258-63(Jan. 25, 1969).

A multichannel $ND^{-1}$ parametrization for the $\pi$-N partial-wave amplitudes is investigated. Using a two-channel, one-input-pole form of the model, fits to all the interesting $\pi$-N partial waves are presented up to pion laboratory kinetic energy ~1.4 BeV. Reasonable fits are obtained for most of the partial waves. An exceptionally good fit is obtained for the $P_{33}$ partial wave, in which the $N^*_{33}$ resonance appears as a quasi-bound state with respect to the higher-mass inelastic channel. Applications of the model are discussed. (auth)

**18923** EQUAL-TIME COMMUTATOR AND SUPERCONVERGENCE SUM RULE. Tomozawa, Yukio (CERN, Geneva, Univ. of Michigan, Ann Arbor). Phys. Rev., 177: 2288-94 (Jan. 25, 1969).

Applying the infinite-momentum technique to the matrix elements of equal-time commutators, superconvergence sum rules are obtained for the zero-mass-pion–nucleon scattering amplitude, which are identical with those derived from dispersion relations, apart from a possible restriction imposed upon trajectories with integer intercepts. Using this result, it is shown that a modification of the equal-time commutation relation of pion fields (or of divergence of the axial-vector currents) motivated by a simple quark model is not compatible with the Pomeranchuk theorem. (auth)

**18924** THEORY OF HIGH-ENERGY POLARIZATIONS. Arnold, Richard C. (Argonne National Lab., Ill.); Logan, R. K. Phys. Rev., 177: 2318-22(Jan. 25, 1969).

Using Regge poles with SU(3) and exchange degeneracy, a theory of all experimentally accessible polarizations arising from pole-pole interferences is presented for pseudoscalar-baryon and baryon-baryon scattering and exchange reactions with all parameters (except for one sign) determined from differential cross-section data. All available data on $\pi$p, Kp, $\bar{p}$p, and pp elastic and $\pi^+p \to K^+\Sigma^+$ polarizations are compared with this theory at the highest available energies, and many predictions are presented. (auth)

## *Strong (Baryon No. ≥ 2)*

*Refer also to abstract 18924.*

**18925** (RHEL/R-166, pp 121-6) SOME REMARKS ON $\pi$-d SCATTERING. Glauber, R. J. (Harvard Univ., Cambridge, Mass. Dept. of Physics).

The shadow effect in diffraction theory calculations for the $\pi$–d scattering cross section is examined. Suggestions are made for the treatment of the cross section defect. (J.W.R.)

**18926** UNITARY PADE APPROXIMANTS IN STRONG INTERACTIONS. THE NUCLEON–NUCLEON SYSTEM. Bessis, D.; Graffi, S.; Grecchi, V.; Turchetti, G. (CEN de Saclay, Gif-sur-Yvette, France). Phys. Lett., 28B: 567-71(Feb. 3, 1969).

The application of the unitary Pade approximation to the nucleon-nucleon system is studied, which yields information about the validity of the Lagrangian field theory and of the approximation itself. The bound state problem, the threshold behavior, the scattering problem, and Regge trajectories are discussed. (L.B.S.)

**18927** STRUCTURE OF HIGH-ENERGY PROTON–PROTON SCATTERING. Abarbanel, Henry D. I.; Drell, Sidney D.; Gilman, Frederick J. (Stanford Univ., Calif.). Phys. Rev., 177: 2458-69 (Jan. 25, 1969).

A suggestion of how to correlate the electromagnetic form factors of the proton with p-p scattering is developed in detail. A new elementary local interaction of current-current form plus a diffractive term is postulated, and an approximately unitary scattering amplitude is constructed for p-p scattering for large fixed s and all values of t, using the Fourier–Bessel transform of the scattering amplitude. The t dependence of the resulting cross section is closely correlated with the fourth power of the electromagnetic form factor of the proton, as suggested first by Wu and Yang, and agrees well with high-energy data ($E_{lab} \approx 30$ BeV) over many decades in values of $d\sigma/dt$. Differences from related models are discussed, as well as further applications and experimental implications of the theory. (auth)

**18928** UPPER ENERGY LIMIT TO THE VALIDITY OF THE GLAUBER THEORY OF SHADOW SCATTERING. Landshoff,

P. V. (Univ. of Cambridge, Eng.). Phys. Rev., 177: 2531-2 (Jan. 25, 1969).

Our knowledge of the structure of the cuts in the complex angular momentum plane requires that the Glauber form for the shadow term in deuteron scattering be invalid at infinite energy. An estimate is made of the maximum energy at which it might be expected to be valid. As a result of the deuteron being very lightly bound, the energy is found to be high, though only a very rough estimate is possible. (auth)

**18929** DIFFRACTION DISSOCIATION AND THE PRODUCTION OF BARYON RESONANCES. Rushbrooke, J. G. (Univ. of Cambridge, Eng.). Phys. Rev., 177: 2357-67 (Jan. 25, 1969).

A model incorporating virtual-meson diffraction scattering followed by a final-state resonant interaction of the meson with an emergent nucleon or isobar is proposed for the production of $I = \frac{1}{2}$ baryon resonances in the reaction $pp \rightarrow pN^*_\zeta$. Absolute predictions are compared with the experimental data relating to enhancements observed in missing-mass experiments. Agreement is favorable in the case of the $P_{11}(1470)$, but otherwise the many resonances predicted by phase-shift analyses complicate the issue and prevent a clear-cut test of the model. The proposed $\Delta P = (-1)^{\Delta J}$ selection rule is discussed in relation to the large cross section predicted by the model for the "forbidden" $S_{11}(1550)$. (auth)

**18930** SELF-CONSISTENT MULTIPLE-QUARK-SCATTERING ANALYSIS AND ITS APPLICATION TO ELASTIC pp SCATTERING. Shrauner, E.; Benofy, L.; Cho, D. W. (Washington Univ., St. Louis). Phys. Rev., 177: 2590-8(Jan. 25, 1969).

A viewpoint is discussed for interpreting elastic scattering of hadrons in terms of a picture in which the hadrons behave as if they are comprised effectively of A distinct subparticles Q which contribute essentially individually to multiple-internal-scattering processes within the hadrons. The formalism of this multiple-internal-scattering picture is developed and applied to the analysis of elastic pp scattering. The discontinuities in the slope of the pp differential cross section at large momentum transfers are interpreted as transitions between domains of momentum transfer that are dominated by successively higher-order multiple-scattering contributions. The structure of the pp cross section is fitted in good detail with a self-consistent analysis that circumvents the necessity for conjectures about the wave functions of internal motion of the subparticles Q within p by exploiting simpler and more direct conditions and conjectures on the effective generalized form factors and scattering amplitudes. The higher-order multiple-scattering contributions are self-consistently calculated in terms of the effective QQ scattering amplitude determined from the region of the first slope. The analysis distinguishes among subparticle models to yield an essentially exclusive fit to the experimental data with the value of the quark number of the proton A = 3, thereby affording corroborative evidence in favor of the $SU_3$ quark model from a non-group-theoretical, dynamical basis. The results are compatible with quarks of very small, or even pointlike, spatial extension as compared to the effective electromagnetic radius of the proton. (auth)

**18931** LOWER BOUNDS ON PHASE SHIFTS FOR THREE-BODY SYSTEMS: n–d QUARTET SCATTERING. Carew, John; Rosenberg, Leonard (New York Univ., University Heights). Phys. Rev., 177: 2599-2603(Jan. 25, 1969).

The Faddeev equations are used to provide a variational-bound formulation of the three-body scattering problem. The present method has the distinct advantage that the Feshbach projection operators, which enter into previous formulations and which are generally difficult to construct, do not appear. The method requires the calculation of a variational approximation to the exact effective potential for the scattering of a particle by a bound two-body system. A reaction matrix is determined by using this effective potential as input to a two-body Lippmann–Schwinger equation which is easily solved numerically. The eigenphase shifts thus obtained provide lower bounds on the true eigenphases for energies below the three-body breakup threshold. To test its practicability, the method is applied to the problem of neutron-deuteron scattering in the quartet state. The results are in agreement with previous calculations and with experiment. (auth)

**18932** UNIVERSAL THEORY OF PRIMARY INTERACTIONS AND NUCLEON–NUCLEON SCATTERING. Chiang, C. C. (Syracuse Univ., N. Y.); Gleiser, R. J.; Huq, M.; Saxena, R. P. Phys. Rev., 177: 2167-81(Jan. 25, 1969).

A dynamical theory of nucleon-nucleon scattering is proposed, employing Sudarshan's universal coupling scheme for all primary interactions. The basic nature of all interactions is assumed to be vector and axial-vector. The contribution to the nuclear force, therefore, comes from vector, axial-vector, and pseudoscalar (longitudinal components of axial-vector fields) meson exchanges. The resulting potential has all the requisite features of a two-nucleon force, notable among them being the natural occurrence of a repulsive core at short distances. The various phase shifts and mixing parameters are then compared with experimental results. This being a parameterless theory, complete agreement is, of course, not expected; however, the over-all agreement of our results with experiments is very good. Another important feature of the present work is the occurrence of a CP-violating nuclear force, responsible for induced CP-violating effects in weak interactions. The consequences of this force with respect to the polarization and asymmetry measurements in nucleon-nucleon scattering are found to be consistent with the available experimental results, which have large uncertainties. (auth)

**18933** SOLUTIONS OF STRONG-COUPLING MESON FIELD THEORY WITH A HARD CORE FOR ELASTIC NUCLEON–NUCLEON INTERACTION. Wagner, Siegfried (Univ., Hamburg, Deutsches Elektronen-Synchrotron, Hamburg). Phys. Rev., 177: 2278-84(Jan. 25, 1969).

In Wentzel's strong-coupling solutions of the fixed-source meson field theory, the nucleon isobars are derived for pion-nucleon interaction. In the limit of strong coupling, the exact solutions of the two-source field equations were also obtained; they contain the transitions between an infinite set of isobaric two-nucleon states. Using the matrix representation given by Fierz, these solutions can be expressed as a coupled system of Schrödinger equations containing infinite matrices for the central and tensor potentials as well as an isobar mass-breaking term. In addition, a core potential of the Wigner type was derived for small separations of the sources; this potential is here idealized as a hard core, independent of the state. This theory contains three parameters: the pion coupling constant $g^2$, the $N^*_{33}$ isobar excitation energy $E_r$, and the core radius $r_c$. Choosing the values $g^2 = 13$, $E_r = 300$ MeV, and $r_c \approx 0.55$ F for these parameters, excellent agreement is obtained for the S-wave phase shifts throughout elastic energy region. The high-angular-momentum phase shifts approach one-pion-exchange phase shifts, and the intermediate phase shifts agree qualitatively below 100 MeV, except for the triplet P. The deviations result essentially from the neglect of the core structure, the absence of spin-orbit forces, and relativistic effects. (auth)

# Particle Invariance Principles and Symmetries

## General

*Refer also to abstracts 18763, 18993, and 18994.*

**18934** (KFKI–31/1968) ON A SYMMETRY OF THE DIRAC EQUATION. Sebestyen, A. (Magyar Tudomanyos Akademia Kozponti Fizikai Kutato Intezete, Budapest). Dec. 18, 1968. 13p. Dep.

It is shown that in a Poincaré covariant theory of a free Dirac particle an implicit symmetry group G emerges. Its representation is of the type $g(\epsilon G) \rightarrow D^{(g)}_{ik}\ (x - x')$ i.e., the effect of a transformation associated with the group element g on the spinor $\psi$ is the following: $\psi'_i(x) = \int D^{(g)}_{ir}\ (x - x')\ \psi_r(x')\ d^4x'$. By requiring the Lagrangian to be invariant under these transformations the generators are explicitly constructed and it is seen that they constitute a six parameter Lie algebra and the neighborhood of the unity is mapped into "matrices" of the kind $\delta_{ik}\ \delta(x - x') + \delta\eta^l\ G^l_{ik}\ (x - x')$. The algebra is locally isomorphic to the SO(4) algebra. By construction the requirements of covariance are fulfilled. (J.F.P.)

**18935** CLASSIFICATION AND COMPLETE REDUCIBILITY OF REPRESENTATIONS OF COMPACT INHOMOGENEOUS GROUPS AND ALGEBRAS. Mirman, R. (Long Island Univ., Brooklyn). J. Math. Phys. (N. Y.), 10: 331-8(Feb. 1969).

The representations of compact inhomogeneous groups are classified according to which types of operators are taken as diagonal. The question of complete reducibility of some of the different classes is discussed. (auth)

**18936** INNER AND RESTRICTION MULTIPLICITY FOR CLASSICAL GROUPS. Delaney, R. M.; Gruber, B. (St. Louis Univ.). J. Math. Phys. (N. Y.), 10: 252-65(Feb. 1969).

For the classical compact Lie groups G, a formula for the multiplicity of weights (called inner multiplicity) is given. This formula relates the inner multiplicity of a group G to the inner multiplicity of a naturally embedded subgroup G′. For the SU(n) groups the formula can be brought into a particularly simple form—namely, a sum over Kronecker symbols—by choosing

the group SU(2) for G'. The multiplicity of irreducible representations of a subgroup G' into which an irreducible representation of a group G decomposes if G is restricted to G' —called restriction multiplicity of G with respect to G' —is related to the inner multiplicity of the group G. (auth)

**18937** INVARIANCE PRINCIPLES. Pais, A. (Rockefeller Univ., New York). pp 317-36 of Spectroscopic and Group Theoretical Methods in Physics. Block, F. (ed.). New York, John Wiley and Sons, Inc., 1968.

The role of invariance principles in the development of physics is reviewed. Two major chapters concerning invariance principles which are important in classical theory are first discussed: (1) the question of invariance of physical laws versus the generally noninvariant nature of boundary conditions; and (2) the connection between invariance under continuous groups and the existence of conservation laws. The remaining part of the discussion is devoted to a review of the role of invariance principles in quantum theory. (L.B.S.)

**18938** ON RACAH COEFFICIENTS AS COUPLING COEFFICIENTS FOR THE VECTOR SPACE OF WIGNER OPERATORS. Biedenharn, L. C. (Duke Univ., Durham, N. C.). pp 59-88 of Spectroscopic and Group Theoretical Methods in Physics. Block, F. (ed.). New York, John Wiley and Sons, Inc., 1968.

The work of Racah on SU(2) is re-examined in order to suggest new points of view and new elements of structure. It is shown that the basic sets of elements of the Racah–Wigner calculus for SU(2), namely the rotation matrices, the Wigner coefficients and the Racah coefficients are all isomorphic structures and are but different realizations of the same abstract idea. It is demonstrated that, correspondingly, the basic product laws for these three sets are but different realizations of a single abstract product law. It is shown that the distinction between these realizations disappears in the classical limit, which provides a natural explanation for the asymptotic relations well known to exist among these three sets. From the point of view of the isomorphy of structure it follows that the Racah coefficients function as vector coupling coefficients in the vector space of Wigner coefficients; this statement is explained in detail. The relevance of these ideas to the general treatment of SU(n) is briefly discussed. (L.B.S.)

**18939** U(3) TRANSPOSITIONS AND THE ISOSPIN–U-SPIN TRANSFORMATION. Gal, A.; Lipkin, H. J. (Weizmann Inst. of Science, Rehovoth, Israel). pp 119-24 of Spectroscopic and Group Theoretical Methods in Physics. Block, F. (ed.). New York, John Wiley and Sons, Inc., 1968.

An alternative derivation of the Chacón–Moshinsky formula for calculating the matrix element of a transposition (2,3) is presented, in which the Racah coefficient appears naturally as the result of decoupling and recoupling of angular momenta. The result is also expressed in a form which is directly applicable to the isospin-U-spin transformation used in elementary particle physics. (L.B.S.)

**18940** IDENTITIES IN THE UNIVERSAL ENVELOPING ALGEBRA OF $SU_3$. Ilamed, Yehiel Lehrer (Soreq Nuclear Research Centre, Israel). pp 125-30 of Spectroscopic and Group Theoretical Methods in Physics. Block, F. (ed.). New York, John Wiley and Sons, Inc., 1968.

A number of relations between elements of the universal associative enveloping algebra of $SU_3$ are given. These are used to derive the main relations which characterize the structure of the subalgebra of the scalars of the universal algebra of $SU_3$. (L.B.S.)

**18941** CONDITION THAT THE IRREDUCIBLE REPRESENTATIONS OF A GROUP, CONSIDERED AS REPRESENTATIONS OF A SUBGROUP, DO NOT CONTAIN ANY REPRESENTATION OF THE SUBGROUP MORE THAN ONCE. Wigner, E. P. (Princeton Univ., N. J.). pp 131-6 of Spectroscopic and Group Theoretical Methods in Physics. Block, F. (ed.). New York, John Wiley and Sons, Inc., 1968.

An attempt is made to find a condition from which a definite form can be specified for all irreducible representations of a group. In order to do this, each representation space is decomposed into orthogonal subspaces, each such subspace being the representation space of an irreducible representation of a subspace. If these irreducible representations are all inequivalent, their subspaces are uniquely given and can be characterized by the corresponding irreducible representation of a subgroup. The procedure is continued with the subgroup until an Abelian subgroup of the last group is reached. As an example, the symmetric group $S_5$ of the permutations of 5 letters is considered. (L.B.S.)

**18942** SOME CONSIDERATIONS ON NONLINEAR REALIZATIONS OF CHIRAL SU(3) X SU(3). Bardeen, W. A.; Lee, B. W. (State Univ. of New York, Stony Brook). Phys. Rev., 177: 2389-97(Jan. 25, 1969).

Nonlinear realizations of the chiral SU(3) × SU(3) symmetry in certain limits of models are considered in which fields transform linearly under the group of transformations which leave the Lagrangian (approximately) invariant. All possible cases of nonlinear realizations of the chiral SU(3) × SU(3), wherein at least the U(2) group generated by isospin and hypercharge is linearly represented, are considered. The connection between the nonlinear realizations and the spontaneous breakdown of the symmetry is made clear. The results are clarified from a group-theoretic point of view, thereby establishing the connection between these results and a more general consideration of Coleman et al. Theoretical and experimental implications of nonlinear realizations of the chiral SU(3) × SU(3) are discussed with reference to the $\kappa$ meson. (auth)

## *Applications (Electromagnetic and Weak)*

*Refer also to abstract 18949.*

**18943** EXPERIMENTAL SETBACK IN CP VIOLATION. Cronin, James W. (Princeton Univ., N. J.). Comments Nucl. Particle Phys., 3: 13-15(Jan.-Feb. 1969).

A brief discussion is given of the experimental situation regarding CP violation. The discussion covers the various K decays and their accompanying CP violation. (J.F.P.)

**18944** ELECTROMAGNETIC AND WEAK TRANSITIONS AND THEIR ALGEBRAIC REPRESENTATION BY CURRENT COMMUTATORS. Harari, Haim (Stanford Univ., Calif.). pp 363-79 of Spectroscopic and Group Theoretical Methods in Physics. Block, F. (ed.). New York, John Wiley and Sons, Inc., 1968.

The possibility of finding a simple algebraic representation for the low-lying baryons and mesons is considered. Starting from a certain set of plausible assumptions, the available data are used for determining all possible solutions for the classification problem. The relations between these solutions and the mixing schemes proposed are then discussed. The analysis indicates that the low lying baryons and mesons can be described at $p = \infty$ in terms of relatively simple representations of the SU(2) × SU(2), SU(3) × SU(3), or $SU(6)_W$ charge algebra. (L.B.S.)

**18945** ELECTROMAGNETIC MASS SPECTRUM OF VECTOR MESONS IN BROKEN $SU_3 \otimes SU_3$. Bose, S. K. (Indian Inst. of Tech., Kanpur). Nuovo Cim., Lett., 1: 333-5(Feb. 21, 1969).

An electromagnetic mass spectrum of vector and axial-vector mesons is found by a generalization of SU(2) nonchiral dynamics to SU(3), on the basis of the quark model assuming both medium-strong and electromagnetic interactions to be present. (J.F.P.)

**18946** EFFECTS OF PARITY NONCONSERVATION AT CAPTURE OF THERMAL NEUTRONS BY DEUTERONS. Moskalev, A. N. (Ioffe Inst. of Physics and Tech., Leningrad). Yadern. Fiz., 9: 163-72(Jan. 1969). (In Russian).

P-odd correlations in the reaction $D(n,\gamma)^3H$ are considered. The $\gamma$-quanta circular polarization and asymmetry in the angular distribution are expressed in terms of the constants characterizing two-nucleon weak interaction. The P-odd effects in this reaction are estimated to be of the order $10^{-5}$ to $10^{-7}$. Experimental measurements of these effects would enable one to reconstruct the amplitude of the weak nucleon-nucleon interaction. (auth)

**18947** CURRENT ALGEBRA, GLASHOW'S MODEL OF CP NONCONSERVATION, AND $K \rightarrow 3\pi$. Holstein, Barry R. (Carnegie-Mellon Univ., Pittsburgh). Phys. Rev., 177: 2417-25 (Jan. 25, 1969).

The Glashow model, which violates CP invariance by inserting two phase factors between the vector and axial-vector currents in the usual weak Hamiltonian, is applied to the decays $K \rightarrow 3\pi$, using standard techniques of current algebra and partially conserved axial-vector current. Experiments on $K \rightarrow 2\pi$ can determine one combination, S, of these phase factors, while possible CP violation in $K \rightarrow 3\pi$ can determine the other combination, D. As a result of calculated enhancement factors, it is shown that present experimental (~10% or more) crude limits on CP violation in $K \rightarrow 3\pi$ already limit D to less than 0.01, and that in possible future experiments on $K \rightarrow 3\pi$ one can hope to see a positive CP-violating effect if the Glashow model is a correct description of CP violation. (auth)

**18948** BOSON MASS SPECTRUM AND PION FORM FACTOR FROM SO(5,2). GENERALIZATION TO SO(m,2). Kyriakopoulos, E. (Univ. of Chicago). Phys. Rev., 177: 2442-8(Jan. 25, 1969).

The SO(5,2) representation whose basis functions are the solu-

tions of the Bethe–Salpeter equation for two scalar quarks interacting via the exchange of the scalar zero-mass boson to form a bound state of zero mass is written as an infinite-dimensional representation for bosons. A general second-order, infinite-component wave equation is given with a reasonable mass spectrum. The ground-state form factor corresponding to this representation is calculated by identifying the electromagnetic current with the current of the equation, in which case the pion form factor is given by $G(t) = [1 - b(\cosh\theta)^2 t/2m]/[1 - (\cosh\theta)^2 t/4m^2]^4$. The mass spectrum and the form factor can easily be generalized to the group SO(m,2) by a simple substitution, and the mass spectra and form factors obtained before in the framework of the group SO(4,2) appear as special cases. (auth)

### Applications (Strong)

*Refer also to abstract 18898.*

**18949** SPONTANEOUS SYMMETRY BREAKING AND THE CABIBBO ANGLE. Solomon, A. I.; Neeman, Y. (Tel-Aviv Univ., Israel). Nuovo Cim., 60A: 108-14(Mar. 1, 1969).

The possibility is studied that the magnitude and direction of the strong breaking of $SU_3$ may be obtained from a self-consistent response equation, symmetric in $SU_3$ apart from driving terms. These driving terms may be either (a) direct: a relatively strong force corresponding to the fifth interaction, or (b) indirect: small perturbations due to electromagnetic and appropriate weak interactions. In the latter case, choosing a model in which the non-leptonic decays have a characteristic angle twice that of the semi-leptonic decays, one obtains the value $\frac{1}{2}\cos^{-1}(\sqrt{3}/2) = 15°$ for the Cabibbo angle. (auth)

**18950** NEGATIVE PARITY BARYON RESONANCES IN THE SU(6) SYMMETRY. Kunszt, Z.; Nagy, T. . (Roland Eoetvoes Univ., Budapest). Acta Phys. Acad. Sci. Hung., 25: 161-76 (1968).

The decay ratios of negative parity baryon resonances are compared with prediction of $SU_W(6)$ symmetry by assigning these resonances to the 540 supermultiplet. Some "semiempirical" mass formulas are also investigated. It turns out that the present experimental data are not inconsistent with such an assignment. Nevertheless, it is believed that not all the negative parity baryon resonances of spins $\frac{1}{2}^-$, $\frac{3}{2}^-$, $\frac{5}{2}^-$ fit into the 540-plet without contradicting experimental values. (auth)

**18951** THE ROLE OF LIE GROUPS IN STRONG INTERACTION PHYSICS. Ne'eman, Y. (Tel-Aviv Univ., Israel). pp 337-61 of Spectroscopic and Group Theoretical Methods in Physics. Block, F. (ed.). New York, John Wiley and Sons, Inc., 1968.

A recent attempt to treat the strong interactions directly by means of an algebraic formulation is described. It is postulated in terms of the Regge-picture of high-energy scattering. The complex-J formalism and its problematics are first reviewed as a physical parametrization of high energy phenomenology. The CNH algebraic approach is then presented and the existing applications are discussed. Possible relations to non-strong currents are mentioned. (L.B.S.)

**18952** THEORIES WITH TOO MUCH SYMMETRY. Doshen, Roger; Frishman, Yitzhak (Inst. for Advanced Study, Princeton, N. J.). Phys. Rev. Lett., 22: 572-6(Mar. 17, 1969).

It is shown that a class of theories, of which Sugawara's theory of currents and certain Yang-Mills type theories are examples, possess a particular symmetry which is not, even approximately, present in the observed strong interactions. The symmetry would imply that all mesons and all massive fermions have partners with opposite parity and opposite charge conjugation. (auth)

**18953** ALGEBRAIC REALIZATIONS OF CHIRAL SYMMETRY. Weinberg, Steven (Massachusetts Inst. of Tech., Cambridge). Contract AT(30-1)-2098. Phys. Rev., 177: 2604-20(Jan. 25, 1969).

The sum of tree graphs for forward pion scattering, generated by any chiral-invariant Lagrangian, is required to grow no faster at high energies than the actual scattering amplitude. In consequence, algebraic restrictions must be imposed on the axial-vector coupling matrix X and the mass matrix $m^2$: For each helicity, X must, together with the isospin T, form a representation of SU (2) ⊗ SU (2), and $m^2$ must behave with respect to commutation with T and X as the sum of a chiral scalar and the fourth component of a chiral four-vector. If it is further assumed that the contribution of tree graphs to inelastic forward pion scattering vanishes at high energy, the two parts of the mass matrix must commute; this fixes various mixing angles, and leads to predictions like $m_\sigma = m_\rho$, $m_{A_1} = \sqrt{2}m_\rho$, $\Gamma_\rho = 135$ MeV, etc. If all pion transitions involved only p-wave pions, then X would form part of the algebra of SU (4), and the mass matrix would behave as the sum of a 1- and a 20-dimensional representation of SU (4); if s-wave transitions are allowed, then the algebra must be enlarged to at least SO (7). (auth)

**18954** UNIVERSALITY, SU(3) SYMMETRY, AND TOTAL CROSS-SECTION RELATIONS. Cutkosky, R. E.; Sarma, K. V. L. (Carnegie-Mellon Univ., Pittsburgh). Phys. Rev., 177: 2253-7 (Jan. 25, 1969).

Total cross-section relations derivable on the basis of SU (3) symmetry and vector-meson universality are examined for their sensitivity to small deviations from exact symmetry and from universality. A discussion is given on the additional information provided by the analysis of the charge-exchange and hypercharge-exchange reactions in meson-baryon scattering. It is pointed out that the relations of Levinson et al. are not sensitive to the departures from universality. According to the present high-energy data, it is found that while SU (3)-symmetric couplings are good to about 10%, the universality hypothesis still remains to be tested. Some tests are indicated which afford a check on the mechanism of SU (3) breaking that is assumed in the analysis. (auth)

**18955** SU(3)-SYMMETRY BREAKING AND DECAYS OF THE $3/2^-$ BARYONS. Golowich, E. (Univ. of Massachusetts, Amherst). Phys. Rev., 177: 2295-30(Jan. 25, 1969).

There exist several coupling-constant sum rules describing the interaction of three arbitrary octets in the presence of octet breaking of SU (3). For decays of the $\frac{1}{2}^-$ baryon $\gamma$ octet to D-wave baryon–pseudoscalar-meson composites, one of the sum rules involves observable modes only. Comparison of the sum rule with experimental data yields a test of the octet-dominance hypothesis, and in addition is potentially a probe of mixing phenomena in excited baryon systems. (auth)

## Field Theories

*Refer also to abstract 18452.*

### Quantum Field Theory

*Refer also to abstract 19004.*

**18956** (AD-672986) PROBLEM OF QUANTUM INTERFERENCE. Final Report, March 1, 1966–February 29, 1968. Aharonov, Yakir; Petersen, Aage (Yeshiva Univ., New York. Belfer Graduate School of Science). June 1968. Contract AF 19(628)-5906. 36p. (AFCRL-68-0338). CFSTI.

An approach is developed for the quantum interference problem that makes the characteristics of the problem more conspicuous and brings out the physical concepts which are adequate for its description. The idea of deterministic quantum experiments is introduced, and a deterministic quantum interference experiment is described. It is shown that the variables that are relevant for describing quantum interference are of the type cos(pl/h bar). The usefulness of these variables in the quantum theory of radiation is outlined. (auth) (USGRDR)

**18957** (ITF-68-26) FIELD AND PARTICLES IN NONLOCAL POTENTIAL MODEL. Troitskii, V. E. (Akademiya Nauk Ukrainskoi SSR, Kiev. Institut Teoreticheskoi Fiziki). 1968. 12p. (In Russian). (CONF-680453-21). Dep.

From 2nd Conference on Axiomatical Field Theory and Theory of Elementary Particles, Kiev, USSR.

In the framework of the model with a nonlocal separable potential and in the nonrelativistic Lie model some relations are established between matrix elements of a scalar field and the S-matrix on the mass shell. (auth)

**18958** (ITF-68-29) SOME CANONICAL TRANSFORMATIONS OF QUANTUM FIELD THEORY AND STATISTICAL MECHANICS. Zav'yalov, O. I.; Sushko, V. N. (Akademiya Nauk Ukrainskoi SSR, Kiev. Institut Teoreticheskoi Fiziki). 1968. 19p. (In Russian). (CONF-680453-19). Dep.

From 2nd Conference on Axiomatical Field Theory and Theory of Elementary Particles, Kiev, USSR.

"Finite-frequency" canonical (generally, nonlinear) transformations and single-parameter groups of similar transformations are considered. A necessary and sufficient condition is found that the above transformations be generated by a unitary operator, i.e., the criterion is given for transformations to be proper ones. It is proved that for any canonical transformation (and even for a single-parameter group of similar transformations) there exists the representation of the operators transformed in which it is proper. (auth)

**18959** (ITF-68-43) CONSTRUCTION OF FIELD THEORY MODEL ON THE BASE OF UNITARITY CONDITION. Medvedev, B. V.; Polivanov, M. K.; Sukhanov, A. D. (Akademiya Nauk Ukrainskoi SSR, Kiev. Institut Teoreticheskoi Fiziki). 1968. 23p. (In Russian). (CONF-680453-18). Dep.

From 2nd Conference on Axiomatical Field Theory and Theory of Elementary Particles, Kiev, USSR.

A solvable model of field theory is formulated. A set of model equations is derived from the spectral representations which account only for the contribution of a single-particle state. The general solution of the model admits two possibilities. One of them which has been considered earlier corresponds to a simple Lagrangian formulation but complicated constructions of formulas in the S-matrix theory. The other possibility is associated with simple relations of the S-matrix theory but a complicated Lagrangian formulation. In conclusion, the second-order operators and the products of Heisenberg fields in the model are considered. (auth)

**18960** (NP-17766(Pt.1)) INTRODUCTION TO THE PHYSICS OF THE ELEMENTARY PARTICLES. I. KINEMATICS. Gerber, H. J. (Geneva Univ. (Switzerland). Laboratoire de Physique Nucleaire Experimentale). 1968. 118p. (In French). Dep.

An introductory course in elementary particle physics is presented. The special relativity theory is considered as a tool and not as a subject of study. Some effects coming from the relativistic transformation laws are considered as, for example, the expansion of time or effects resulting from the relativistic formulation of the conservation of energy and momentum. Only the results that can be derived in a classical fashion are considered. Emphasis is placed on the application of typical examples in the study of the kinematics of elementary particles, rather than a complete formulation of kinematic relations. (tr-auth)

**18961** ANALYTICITY AND NON-LINEAR FIELD THEORIES. Fried, H. M. (Brown Univ., Providence). New Phys. (S. Korea), Suppl., 7: No. 2, 23-5(June 1968).

It is pointed out that, although nonlinear field theories may not require substractions, they may be expected to violate certain requirements of analyticity and unitarity. (J.F.P.)

**18962** DE SITTER SYMMETRIC FIELD THEORY. I. ONE-PARTICLE THEORY. Bakri, Mahmoud M. (Cairo Univ.). J. Math. Phys. (N. Y.), 10: 298-320(Feb. 1969).

The formal structure and the free-particle solutions of the field equations $(S_{\mu\nu}p_\nu + m\gamma_\mu)\psi = p_\mu\psi$, derived recently for realizations of the inhomogeneous de Sitter group, are discussed. The enveloping algebra of the group is developed, and the covariance of the field equations under the five-dimensional rotations C, P, and T is proved. Bhabha's representation of the matrices $\gamma_\mu$ is completed. Observables, expectation values and the scalar product are defined, and classical conservation laws are derived. The field equations are derived from a variational principle for the usual Lagrangian density $\bar{\psi}(-i\gamma_\mu\partial_\mu + m)\psi$ under a certain restriction. The free-particle solutions of the field equations are obtained in the canonical and the extreme relativistic representations. The connections between the wave functions in these representations, and also in the Foldy-Wouthuysen representation are derived. (auth)

**18963** CLASS OF MODELS IN QUANTUM FIELD THEORY. de Brucq, Denis (CIENES, Santiago, Chile); Tirapegui, Enrique. Compt. Rend., Ser. A and B, 267: 1049-52(Nov. 13, 1968). (In French).

It was shown previously (Nuovo Cimento, 53A: 69(1968)) that the propagators of an extended class of models can be expanded in continued fractions. It is shown that the Hamiltonian of these models can be represented by Jacobi matrices. This property allows the eigenvalue problem to be connected to the theory of continued fractions. (tr-auth)

**18964** THE STRUCTURE OF SINGULARITIES OF FEYNMAN INTEGRALS. Greenman, J. V. (Univ. of Essex, Colchester, Eng.). Nuovo Cim., 60A: 69-85(Mar. 1, 1969).

The structure of the pinch manifold of second-type singularities of Feynman integrals is studied in detail. Further, it is argued that the strength of second-type singularities, in contrast to the strength of Landau singularities, does not in general decrease with the order of the graph. Finally, a simple analysis of mixed-type singularities is given using a modified $\alpha$-representation for the Feynman integral and a prescription for determining the strength of these singularities. (auth)

**18965** NON-EQUIVALENT REPRESENTATION IN QUANTUM FIELD THEORY AND MEASUREMENT THEORY. Grib, A. A. Vestn. Leningrad. Univ., No. 16, Ser. Fiz. Khim., No. 3, 16-23 (Aug. 1968). (In Russian).

Nonequivalent representations of commutation relations in quantum field theory are discussed. The connection of classification of these representation with that of generalized random fields is investigated. New aspects of the theory of measurement in quantum field theory are discussed. (auth)

**18966** ASYMPTOTIC CONDITION IN THE ZACHARIASEN-THIRRING MODEL. Karwowski, W.; Sznajder, N. (Univ., Wroclaw). Acta Phys. Pol., 34: 1057-62(Dec. 1968).

The asymptotic condition in the Zachariasen-Thirring model is discussed. The convergence of the product of operators is proved in the weak and strong limits. (auth)

**18967** MULTIPLICATION OF DISTRIBUTIONS. Berntsen, Svend (Danmarks Ingeniorakademi, Maskinafdelingen). J. Math. Anal. Appl., 25: 435-45(Feb. 1969).

A definition of products of distributions is given such that all expressions occurring in quantum field theory are finite and well-defined, and such that a new formulation of renormalization theory is obtained. Tempered distributions are considered. (J.F.P.)

**18968** NONLINEAR MODEL IN QUANTUM FIELD THEORY. Mezei, F. (Roland Eoetvoes Univ., Budapest). Acta Phys. Acad. Sci. Hung., 25: 215-26(1968).

The mass spectrum of a nonlinear real scalar field was sought for using Ritz's variational method. In the case of suitable renormalization 1, 2 or 3 finite values of rest mass were found. The different types of these excitations belong to different inequivalent representations of the field operators. (auth)

**18969** THE IMPOSSIBILITY OF DEDUCING THE CONSERVATION OF THE MOMENTUM-ENERGY OF A VARIATIONAL PRINCIPLE IN THE WHEELER AND FEYNMAN ELECTRODYNAMICS. Conort, Alain (Institut Henri Poincare, Paris). Compt. Rend., Ser. A, B, 267: 857-60(Nov. 25, 1968). (In French).

It appears that the relativistic dynamics of points in interaction can not, at least in the particular case of the Wheeler and Feynman theory, agree with a variational principle. This can be the result of the nonlocal interactions which appear when an attempt is made to express the fields as a function of the currents which create them. (tr-auth)

**18970** THE MASS FAULT OF A BOUND SYSTEM IN THE WHEELER AND FEYNMAN ELECTROMAGNETIC INTERACTION THEORY. Costa de Beauregard, Olivier (Institut Henri Poincare, Paris). Compt. Rend., Ser. A, B, 267: 853-6(Nov. 25, 1968). (In French).

The expression for the theorem of the kinetic energy, taking into consideration the electrostatic potential energy and the equivalence between masses and charges, is generalized on the basis of the assumption that the Darwin theory can be considered as the $c^{-2}$ approximation of the completely covariant theory, without radiation, of the Wheeler and Feynman electromagnetic interaction. (J.S.R.)

**18971** SPECIAL THEORY OF RELATIVITY AND THE PROBLEM OF THE UNIVERSAL CONSTANTS. Paviopoulos, T. G. (Naval Electronics Lab. Center, San Diego, Calif.). Nuovo Cim., 60B: 93-106(Mar. 11, 1969).

The basis of the special theory of relativity (STR), when analyzed, shows that this theory requires, as a prerequisite, Maxwell's electromagnetic theory for empty space. The special principle of relativity is extended to hold for expanded electrodynamic theories, an example of which is presented. The extension of the theory is derived from dimensional considerations. The speed of light c, and Planck's constant h, are Lorentz-invariant, but the universal length $l_0$ is not. The presence of a universal length $l_0 \sim 10^{-14}$ cm, however, in any theory on elementary particles, is required from dimensional consideration. In the extended theory of relativity, $l_0$ is, like c, an invariant by definition. Additionally, the static case of the extended wave equation, which describes the propagation of signals, may be significant for describing electric and nuclear potentials. (auth)

**18972** NONUNITARY REPRESENTATIONS OF THE POINCARE GROUP AND FIELD THEORY OF UNSTABLE PARTICLES. Kawai, T.; Goto, M. (Osaka City Univ.). Nuovo Cim., 60B: 21-39(Mar. 11, 1969).

A particular type of nonunitary irreducible representation of the Poincare group is discussed which is suitable to describe an unstable field with definite mass, decay width, and spin. The

transformation property of the wave function is given and the wave equation, which may be called a generalized Bargmann–Wigner equation, is derived. The wave function is regarded as a distribution and its Fourier transform on the line C in the complex momentum space is introduced. The wave packet, which moves with velocity $v \doteq \hat{v}$ as a whole and mean lifetime $\tau \doteq \tau_0/\sqrt{1-\hat{v}^2}$, is constructed. ($\tau_0$ is the lifetime in the rest system.) The discrepancy of $\tau$ from the correct lifetime is smaller than 1% for the known elementary particles. The quantization of the scalar unstable field with complex mass M is carried out. The commutation relation for the field operator satisfies the requirement of microscopic causality. Under a certain condition, the invariant delta-function $\Delta_+(x,M)$ coincides with $\Delta(x,M)$ and the commutation relation coincides with that of ref. 4 except for the phase factor $(M/M^*)^{\frac{1}{2}}$. (auth)

**18973** CONDITIONS FOR COMPOSITENESS IN FIELD THEORY. Cordero, P. (International Atomic Energy Agency, Trieste, Italy). Nuovo Cim., 60B: 217-27(Mar. 11, 1969).

The Fried–Jin derivation of the condition Z = 0 is re-examined making explicit use of the HNZ construction of a composite-particle field. This leads to another condition for compositeness originally due to Nishijima. The latter condition is shown to have important implications concerning the vertex renormalization constants and the mass shift. (auth)

**18974** ENERGY AND CAUSALITY. Gerlach, Bernd; Gromes, Dieter; Petzold, Joachim (Univ., Marburg, Ger.). Z. Phys., 221: 141-57(1969). (In German).

Problems arising from the requirement that the propagation of energy density is causal are discussed. (auth)

**18975** SOLUTIONS OF A FOURTH-ORDER BETHE–SALPETER EQUATION. Patergnani, G. (Univ., Padua). Z. Phys., 220: 330-6(1969).

A Bethe–Salpeter equation with interaction up to the fourth order is solved numerically for a bound state with energy equal to zero. It is found that the fourth order term is important even for very heavy exchanged mesons, and for angular momentum equal to 1. The correction found is to be considered the highest limit for the corrections with energy different from zero. (auth)

**18976** ON CERTAIN ANALYTICAL PROPERTIES OF THE GREEN FUNCTION AND THE GOLDSTONE THEOREM. Crisan, M. (Academie de la R. S. Roumanie, Cluj). Phys. Lett., 28A: 366-7(Dec. 16, 1968). (In French).

In extension of the considerations published previously, it is shown that with the application of the Green function method it is possible to develop a demonstration of the Goldstone theorem in a more general case than that considered by Lange and Wagner. (tr-auth)

**18977** RELATIVISTIC TWO-BODY PROBLEM. Tugov, I. I. (Lebedev Inst. of Physics, Moscow). Yadern. Fiz., 9: 193-200 (Jan. 1969). (In Russian).

A new method is proposed to solve the Bethe–Salpeter equation in the ladder approximation for bound states of two spinless particles interacting through the scalar massless field. Unlike the conventional approach, the Bethe–Salpeter equation is presented as a second order differential equation in the p representation. The equation obtained is given in canonic form corresponding to the free motion in the curvilinear space $V_4$ with the metric tensor $a^{ij} = F_+F_-\delta^{ij}$. The Bethe–Salpeter equation is separable in the coordinate system corresponding to the group properties of the space $V_4$. The solutions are products of hyperspherical functions $Y_{Nlm}(\alpha,\theta,\varphi)$ and the radial part which is the solution of the Hoin equation. (auth)

**18978** INVARIANT EXPANSION OF SOLUTIONS OF RELATIVISTIC EQUATIONS. Agamaliev, A. K.; Atakishiev, N. M.; Verdiev, I. A. (Inst. of Physics and Mathematics, Baku). Yadern. Fiz., 9: 201-11(Jan. 1969). (In Russian).

Relativistic equations for the vector field with non-zero mass are considered. Relativistic-invariant expansion of the solutions in and off the light cone is obtained. It is shown that in the non-relativistic limit the total set of functions given on the hyperboloid transforms into a set of functions given in the three-dimensional space. (auth)

**18979** DERIVATION OF ADLER'S DIVERGENCE CONDITION FROM THE FIELD EQUATIONS. Hagen, C. R. (Univ. of Rochester, N. Y.). Phys. Rev., 177: 2622-3(Jan. 25, 1969).

It is shown that the electromagnetic corrections to the divergence of the axial-vector current as derived by Adler within the framework of perturbation theory can be inferred directly from the field equations. An essential ingredient in this approach consists of redefining the current operator in terms of a limiting procedure which is explicitly gauge-invariant. (auth)

**18980** ALGEBRA OF FIELDS AND WEINBERG'S SECOND SUM RULE. Mitter, P. K.; Swank, L. J. (Univ. of Maryland, College Park). Phys. Rev., 177: 2582-3(Jan. 25, 1969).

In realistic SU(3) × SU(3) field-algebra Lagrangians, in which the unrenormalized masses of the spin-1 multiplets are split, nonminimal couplings are necessary. It is shown that when nonminimal couplings are allowed, Weinberg's second sum rule, relating spin-1 chiral partners, may be violated in both the SU(2) × SU(2) and SU(3) × SU(3) algebras even when all currents are conserved. (auth)

**18981** GRIBOV'S REGGEON-GRAPH TECHNIQUE. Winbow, G. A. (Univ. of Cambridge, Eng.). Phys. Rev., 177: 2533-9 (Jan. 25, 1969).

Gribov has recently extracted the high-energy behavior of some Feynman graphs using a parametrization due to Sudakov. His results can be systematically written in terms of Reggeon graphs. He postulates that the asymptotic form of higher-order graphs can also be written this way. Some of Gribov's results are discussed and it is shown that they depend on (i) the formation of pinches as $s \to \infty$, (ii) a certain restriction on the region of integration. From this discussion Gribov's results are extended to graphs of arbitrarily high order and the graph technique is confirmed. (auth)

**18982** GEOMETRIC FORMULA FOR CURRENT-ALGEBRA COMMUTATION RELATIONS. Hermann, Robert (Univ. of California, Santa Cruz). Phys. Rev., 177: 2449-52(Jan. 25, 1969).

A purely algebraic formalism is introduced in order to describe the relation between current algebras and Lagrangian field theory. It is then applied to the description in differential-geometric terms of the equal-time commutation relations for currents defined by Lagrangians derived from Riemannian metrics on internal-symmetry spaces. (auth)

**18983** QUANTUM FIELD THEORIES WITH DEGENERATE LAGRANGIANS. Hermann, Robert (Univ. of California, Santa Cruz). Phys. Rev., 177: 2453-6(Jan. 25, 1969).

An algebraic approach is presented to the problem of setting up quantum field theory for classical fields with degenerate Lagrangians. To this end, an algebraic generalization of Dirac'c formalism of Poisson brackets with constraints is developed. (auth)

**18984** FIELD-CURRENT IDENTITIES, BROKEN SYMMETRIES, CURRENT-MIXING MODEL, AND THE ALGEBRA OF GAUGE FIELDS. Kang, Kyungsik (Brookhaven National Lab., Upton, N. Y. Brown Univ., Providence). Phys. Rev., 177: 2439-41(Jan. 25, 1969).

It is shown in general that the algebra of the massive gauge fields can recover the current-algebra relations only for the current-mixing model, and how the possible modifications of the spectral-function sum rules can be made within the framework of the gauge-field theory. It is also shown that the Oakes–Sakurai generalization of the first sum rule is a natural consequence of the current-mixing model. (auth)

**18985** AXIAL-VECTOR VERTEX IN SPINOR ELECTRODYNAMICS. Adler, Stephen L. (Inst. for Advanced Study, Princeton, N. J.). Phys. Rev., 177: 2426-38(Jan. 25, 1969).

Working within the framework of perturbation theory, it is shown that the axial-vector vertex in spinor electrodynamics has anomalous properties which disagree with those found by the formal manipulation of field equations. Specifically, because of the presence of closed-loop "triangle diagrams," the divergence of axial-vector current is not the usual expression calculated from the field equations, and the axial-vector current does not satisfy the usual Ward identity. One consequence is that, even after the external-line wave-function renormalizations are made, the axial-vector vertex is still divergent in fourth- (and higher-) order perturbation theory. A corollary is that the radiative corrections to $\nu_l$-l elastic scattering in the local current-current theory diverge in fourth (and higher) order. A second consequence is that, in massless electrodynamics, despite the fact that the theory is invariant under $\gamma_5$ transformations, the axial-vector current is not conserved. In an Appendix the uniqueness of the triangle diagrams is demonstrated, and a possible connection between our results and the $\pi^0 \to 2\gamma$ and $\eta \to 2\gamma$ decays is discussed. In particular, it is argued that as a result of triangle diagrams, the equations expressing partial conservation of axial-vector current (PCAC) for the neutral members of the axial-vector-current octet must be modified in a well-defined manner, which completely alters the PCAC predictions for the $\pi^0$ and the $\eta$ two-photon decays. (auth)

**18986** SELF-ENERGY AND SCATTERING PHASE SHIFTS IN MODEL FIELD THEORIES. Fishbane, Paul M. (Univ. of Wisconsin, Madison). Phys. Rev., 177: 2323-7(Jan. 25, 1969).

The mass shift is shown to be a particularly simple integral over scattering phase shifts for the Lee model and for an extended Lee model with inelasticity. Possible extensions of this result and its relation to other similar fomulas are discussed. (auth)

**18987** INTERACTIONS OF VECTOR BOSON IN THE KLEIN–GORDON AND KEMMER–DUFFIN THEORIES. Ainsaar, A. Tr. Inst. Fiz. Astron., Akad. Nauk Est. SSR, No. 33, 94-105 (1967). (In Russian).

The general equations of correspondence between the Klein–Gordon and Kemmer–Duffin field operators in the interaction and Heisenberg representations are given. The analogical problem of scalar boson is solved. The question of correspondence of the interaction Lagrangians is discussed. The cases of one-boson and two-boson interactions are studied as examples. (auth)

**18988** PARAMETRIZATION OF THE SPIN DENSITY MATRIX. Kyiv, M.; Ots, I. Tr. Inst. Fiz. Astron., Akad. Nauk Est. SSR, No. 33, 68-76(1967). (In Russian).

Problems of the parametrization of the density matrix given in the form $\rho = U^{+}\rho_{D}U$ are examined. The matrices U are found if $\rho$ is invariant under certain transformation. A formula for the maximal number of parameters is given. (auth)

**18989** QUANTIZATION OF THE CHARGED SPIN-3/2 FIELD. Gupta, Suraj N.; Repko, Wayne W. (Wayne State Univ., Detroit). Phys. Rev., 177: 1921-8(Jan. 25, 1969).

The canonical quantization of the spin-$\frac{3}{2}$ field is carried out in the presence of electromagnetic interaction by a suitable choice of canonical variables, which satisfy the usual commutation relations as well as Heisenberg's equations of motion. The present investigation shows that the canonical formalism can be developed consistently for the charged spin-$\frac{3}{2}$ field despite the enormous mathematical complications which appear in the treatment of high-spin fields. (auth)

**18990** NONRELATIVISTIC QUANTUM MECHANICS FORMULATED IN TERMS OF CURRENTS. Gross, David J. (Harvard Univ., Cambridge, Mass.). Phys. Rev., 177: 1843-7 (Jan. 25, 1969).

The nonrelativistic quantum mechanics of interacting spinless bosons or fermions is formulated in terms of particle and current densities. Natural physical requirements on the structure of the physical states allow one to construct explicitly the physical Hilbert space, and to construct annihilation and creation operators for either bosons or fermions. The problem of extending such methods to the relativistic case is discussed. (auth)

**18991** CURRENT ALGEBRA AND INFINITE-COMPONENT FIELDS. Bebie, H.; Ghielmetti, F.; Gorge, V.; Leutwyler, H. (Univ., Bern). Phys. Rev., 177: 2133-45(Jan. 25, 1969).

A second-order infinite-component wave equation is analyzed in detail. It is shown that a complete set of solutions contains timelike momenta (physical states) as well as spacelike and lightlike momenta (ghosts). The timelike solutions describe particles of spin $\frac{1}{2}$, $\frac{3}{2}$, $\frac{5}{2}$, . . . with a nondegenerate mass spectrum. The wave equation is used to construct a model of local current algebra at infinite momentum, and it is shown that this model coincides with the so-called hydrogen model which has been obtained as a particular solution of the current-algebra relations. The hydrogen model, too, is known to contain unphysical states; they correspond to the ghost solutions of the wave equation. It is proved that for finite mass splitting, the current-algebra relations are not satisfied unless transitions to ghosts are taken into account. On the other hand, it is shown that as long as one restricts oneself to an expansion in powers of the mass splitting to arbitrary finite order, the ghosts do not contribute. (auth)

**18992** INFINITE-COMPONENT FIELD MODEL OF THE LOCAL VECTOR AND AXIAL-VECTOR CURRENT ALGEBRA. Bebie, H.; Ghielmetti, F.; Gorge, V.; Leutwyler, H. (Univ., Bern). Phys. Rev., 177: 2146-58(Jan. 25, 1969).

Gell-Mann, Horn, and Weyers have constructed a nontrivial solution of the local current-algebra relations at infinite momentum by making use of an infinite-component wave equation first studied by Abers, Grodsky, and Norton. A detailed account is given of the properties of this wave equation and its relation to current algebra. In particular, a complete set of solutions including timelike as well as spacelike momenta are explicitly exhibited. (auth)

**18993** STRUCTURE OF PHENOMENOLOGICAL LAGRANGIANS. II. Callan, Curtis G. Jr. (Harvard Univ., Cambridge, Mass.); Coleman, Sidney; Wess, J.; Zumino, Bruno. Phys. Rev., 177: 2247-50(Jan. 25, 1969).

The general method for constructing invariant phenomenological Lagrangians is described. The fields are assumed to transform according to (nonlinear) realizations of an internal symmetry group, given in standard form. The construction proceeds through the introduction of covariant derivatives, which are standard forms for the field gradients. The case of gage fields is also discussed. (auth)

**18994** STRUCTURE OF PHENOMENOLOGICAL LAGRANGIANS. I. Coleman, S. (Harvard Univ., Cambridge, Mass.); Wess, J.; Zumino, Bruno. Phys. Rev., 177: 2239-47(Jan. 25, 1969).

The general structure of phenomenological Lagrangian theories is investigated, and the possible transformation laws of the phenomenological fields under a group are discussed. The manifold spanned by the phenomenological fields has a special point, called the origin. Allowed changes in the field variables, which do not change the on-shell S matrix, must leave the origin fixed. By a suitable choice of fields, the transformations induced by the group on the manifold of the phenomenological fields can be made to have standard forms, which are described in detail. The mathematical problem is equivalent to that of finding all (nonlinear) realizations of a (compact, connected, semisimple) Lie group which become linear when restricted to a given subgroup. The relation between linear representations and nonlinear realizations is discussed. The important special case of the chiral groups SU (2) × SU (2) and SU (3) × SU (3) is considered in detail. (auth)

## *Gravitation and General Relativity*

**18995** (ITF–68–44) STOCHASTIC MOTION OF A RELATIVISTIC PARTICLE. Chernikov, N. A. (Akademiya Nauk Ukrainskoi SSR, Kiev. Institut Teoreticheskoi Fiziki). 1968. 148p. (In Russian). (CONF-680647–2). Dep.

From Conference on Composite Models of Elementary Particles, Kiev, USSR.

The problem of stochastic motion of a particle is formulated so that the world time plays no special role but the proper time of the particle appears to be important. This allows one to write down the relativistic kinetic equation. The problem of relativistic collision integral turns out to be a particular case of the general problem. For representation of quantities which enter the collision integral the theory of relativistic particles scattering is developed in terms of the Lobachevsky velocity-space. Some problems of penetration of relativistic particles through the matter are formulated and solved. (auth)

**18996** GENERALIZATION OF GREEN'S THEOREM. Goldberg, Joshua N. (Syracuse Univ., N. Y.); Newman, Ezra T. J. Math. Phys. (N. Y.), 10: 369-70(Feb. 1969).

For a system of field equations which is derivable from a Lagrangian whose density is homogeneous quadratic in the first derivatives of the field variables $y_{A,\mu}$ and homogeneous of degree n in the undifferentiated field variables $y_A$, one has the identity $(n+1)z_A L^A(y) - y_A M^A(y,z) \equiv t^{\rho}{}_{,\rho}$, where $M^A(y,z)$ is the first-order change in the field equations $L^A(y) = 0$ under the mapping $y_A \rightarrow y_A + z_A$. The specific example of general relativity is discussed. (auth)

**18997** T-MODELS OF "SPHERE" IN GENERAL RELATIVITY THEORY. Ruban, V. A. (Ioffe Inst. of Physics and Tech., Moscow). JETP Lett. (USSR) (Engl. Transl.), 8: 414-17(Dec. 20, 1968).

Translated from Zh. Eksp. Teor. Fiz. Pis'ma Redaktsiyu, 8: 669-73(Dec. 5, 1968).

It is assumed that Tolman's solution represents all the possible general relativity theory nonstatic models of a sphere made of dust without pressure. But in the integration of Einstein's equations it is implicitly assumed that the co-moving condition $G^1_1$ does not reduce to a trivial identity. Therefore, Tolman's solution implies an additional requirement with respect to the initial metric, namely $(\partial R/\partial \chi)_T \neq 0$, and accordingly with respect to the permissible distributions of the relativistic per-unit energy of the dust, $W = 1 + f > 0$, which determines the ratio of the increments of the current active and proper masses of the sphere and also the geometry of the space-like cross sections. Actually these limitations do not follow from spherical symmetry or from the field equations, and thus sight is lost of a special type of paradoxical configuration of the general-relativity sphere, having a constant active mass at an arbitrary total rest mass of the constituent dust with $W \equiv 0$, namely T-models for which the co-moving reference frame is also the synchronous T-system. This additional class of exact internal solutions is pointed out for this metric, and its important physical consequences are discussed. (J.F.P.)

**18998** SEMIGEODETIC TWO-VARIABLE SOLUTIONS OF THE EINSTEIN'S EMPTY SPACE EQUATIONS AND THE CORRESPONDENCE PRINCIPLE. Koppel, A. Tr. Inst. Fiz.

Astron., Akad. Nauk Est. SSR, No. 33, 39-53(1967). (In Russian).

Gravitational fields in empty space were investigated on the basis of the correspondence principle formulated by Keres. The metric tensor is assumed to be of a semigeodetic orthogonal form depending on two variables. In the Newtonian limit, metric forms of two different types exist corresponding to these relativistic fields. The explicit formulas for the Newtonian potentials were found, and the space symmetry properties of the gravitational fields under consideration are discussed, making use of the shape of equipotential surfaces in the Newtonian limit. On the basis of the correspondence principle it has been proved that in the nonrelativistic limit, the static one-variable metric in empty space describes either homogeneous gravitational field, or axially symmetric field of an infinite rod, thus maintaining the validity of the commonly accepted interpretation. The correspondence principle was also applied to discuss the solutions of Einstein's equations obtained in a previous paper. (auth)

**18999** ON THE EXACT SEMIGEODETIC TWO-VARIABLE SOLUTIONS OF EINSTEIN'S EMPTY SPACE EQUATIONS. Koppel, A. Tr. Inst. Fiz. Astron., Akad. Nauk Est. SSR, No. 33, 18-38(1967). (In Russian).

The two-variable semigeodetic orthogonal metric form is studied. The problem of finding exact non-Galilean solutions of Einstein's equations for empty space is discussed in three special cases. The general structure of the solutions was determined in the case if one of the components $g_{11}$, $g_{22}$ or $g_{33}$ of the metric tensor is constant. By separating variables in the metric tensor components, four types of solutions are obtained, one of them being of the Narlikar–Karmarkar type. If the components depend on the quantity $\xi \equiv t - x_1/c$ only, the general solution obtained contains a function satisfying an ordinary differential equation of the first order. It is shown that the Narlikar–Karmarkar solution is the only non-Galilean one admitting the representation in the three-dimensional Euclidean space. The investigation of coefficients in their general semigeodetic metrical form show that if they all contain a certain common time factor while the dependence on spacial coordinates is arbitrary, the Einstein's empty space equations admit the Galilean solutions only. It follows that the Rastall solution, considered as describing the exterior gravitational field of an isolated particles system, is in fact a Galilean one. (auth)

**19000** ON THE CALCULATION OF THE NEWTONIAN APPROXIMATION TO THE RELATIVISTIC GRAVITATIONAL FIELD. Unt, V. Tr. Inst. Fiz. Astron., Akad. Nauk Est. SSR, No. 33, 54-9(1967). (In Russian).

The equations obtained from the Einstein equations by the limiting process $c \to \infty$ are satisfied by such components of the metric tensor which can be interpreted as the components of the field of velocities in Euclidean three-space. The vortex-free case of the field of velocities is considered and the potentials of the field of velocities in the form of linear expansion are found. (auth)

**19001** DERIVATION OF THE TEN EINSTEIN FIELD EQUATIONS FROM THE SEMICLASSICAL APPROXIMATION TO QUANTUM GEOMETRODYNAMICS. Gerlach, Ulrich H. (Princeton Univ., N. J. Battelle Memorial Inst., Columbus, Ohio). Phys. Rev., 177: 1929-41(Jan. 25, 1969).

All ten Einstein field equations are derived from (a) a single equation, the Einstein–Hamilton–Jacobi equation for general relativity, and (b) the principle of constructive interference of de Broglie waves in superspace. In this derivation the manifestly covariant Hamiltonian equations of general relativity are obtained by introducing Tomonaga's many-time parametrization. (auth)

**19002** THE WAVE SOLUTIONS OF EINSTEIN'S FIELD EQUATIONS IN THE SECOND APPROXIMATION. Unt, V. Tr. Inst. Fiz. Astron., Akad. Nauk Est. SSR, No. 33, 3-17(1967). (In Russian).

The fast approximation method is used to examine the wave solutions of Einstein's equations in the second approximation. Some difficulties which the research workers are confronted with are considered. In the second part approximate Einstein's equations are given in a form suitable for further application. In the third part of the paper gravitational waves described (in a suitably chosen coordinate system) by the metric tensor of the form $g_{\mu\nu} = g_{\mu\nu}(x^1, t)$ are considered. It is shown that in the case of such flat gravitational waves no regular second approximation to $g_{\mu\nu}$ exists. No coordinate condition was used; it was supposed that the corrections to the Galilean metric $h_{\mu\nu}$ in the first approximation have the form $h_{1\mu\nu} = h_{1\mu\nu}(x^1 - t)$. In the fourth part gravitational waves from sources of finite size are considered. Approximate asymptotic values for $g_{\mu\nu}$ in the wave zone are found. The relations obtained in the previous part of this paper for $h_{1\mu\nu}$ in the case of flat gravitational waves are used for asymptotic values of $h_{\mu\nu}$ as coordinate conditions. The mass of the gravitating system M and the second order quantity $-\Delta M$ enter into the expressions for $g_{\mu\nu}$ symmetrically, and $\Delta M$ can be interpreted as mass carried away by gravitational waves. (auth)

## Scattering Theory

*Refer also to abstracts 18399, 18752, 18771, 18881, 18928, and 19389.*

**19003** (ITF-68-38) FURTHER RESTRICTIONS ON THE HIGH-ENERGY BEHAVIOUR OF SCATTERING AMPLITUDE. Lomsadze, Yu. M.; Kontrosh, E. E.; Tokar', S. S. (Akademiya Nauk Ukrainskoi SSR, Kiev. Institut Teoreticheskoi Fiziki). 1968. 23p. (CONF-680453-16). Dep.

From 2nd Conference on Axiomatical Field Theory and Theory of Elementary Particles, Kiev, USSR.

The Modified Meyman theorem 1 is proved. Using it the Froissart-Martin upper bound is lowered for the scattering amplitude $f(s) \equiv f(s,t=0)$ under various assumptions about the behavior of $H(s) \equiv \mathrm{Im}f(s)/\mathrm{Re}f(s)$ for physical $s \to \infty$ in the absence of the pathologically strong oscillations of f(s) in the strictly formulated meaning. The Meyman theorem 1 is quoted and by making use of it new restrictions are obtained on the high-energy behavior of f(s). The restrictions are strengthened if the amplitude f(s) is free from the very strong oscillations–but again in the strictly formulated meaning. In all the proofs, one makes use of the amplitude analyticity only in the upper s-halfplane and takes into account that f(s) for real s is a distribution rather than a usual function. Some of the results obtained strenthen the results obtained recently by Khuri, Kinoshita and Vernov. All the results are extended to the case of arbitrary binary reactions. The advantages of introducing the Meyman asymptotic amplitudes are pointed out. (auth)

**19004** (ITF-68-46) SCATTERING BY "NONPHYSICAL" POTENTIALS: ANALYTICITY IN THE COUPLING CONSTANT. Lomsadze, Yu. M. (Akademiya Nauk Ukrainskoi SSR, Kiev. Institut Teoreticheskoi Fiziki). 1968. 23p. (CONF-680453-17). Dep.

From 2nd Conference on Axiomatical Field Theory and Theory of Elementary Particles, Kiev, USSR.

A general method is given for investigating the nonrelativistic scattering by arbitrary "nonphysical" potentials $\lambda V(r) > 0(r^{-2})$ when $r \to 0$, reducing the problem of calculating the partial-wave scattering amplitude to solving the inhomogeneous Volterra equation which may be iterated an arbitrary number of times. In contrast to the scattering by the "physical" potentials $\lambda V(r) \leq 0(r^{-2})$ when $r \to 0$, the amplitude of scattering by the "nonphysical" potentials possesses inevitably an unmovable singularity at the point $\lambda = 0$ as well as an essential singularity at the infinity in the s plane. The possible situation with the structure of the $g^2$ plane of field-theory scattering amplitude (g is the physical coupling constant) is discussed in three cases: quantal electrodynamics, unrenormalizable theories and renormalizable theories of strong interactions. (auth)

**19005** (NYO-1932(2)-146) THREE-BODY CALCULATIONS WITH LOCAL POTENTIALS. Brayshaw, D. D. (Columbia Univ., New York). [1968]. 59p. Dep. CFSTI.

A two-term separable approximation to the two-particle t-matrix is developed which preserves exact behavior at each bound state or resonance pole. While introducing no additional singularities, the approximation also produces the exact right-hand cut. This separable approximation is applied to the three-particle scattering problem with local potentials, and numerical results are obtained for the three-body binding energy in the case of the Yukawa and exponential potentials. A prescription is given for increasing the accuracy of this approach by systematically increasing the number of separable terms. This procedure is tested numerically, as is a method for estimating the error in such calculations. Binding energy results are also presented for a modified pole approximation, and a simple explanation is given for the infinite binding energy phenomenon observed by Osborn for separable potentials. (auth)

**19006** ANALYTICITY REQUIREMENT FOR REGGE POLES AND BACKWARD UNEQUAL-MASS SCATTERING. II. Kim, K. J.; Kim, Y. S. (Univ. of Maryland, College Park). New Phys. (S. Korea), Suppl., 7: No. 2, 39-40(June 1968).

The modified Regge amplitude is evaluated exactly for the backward unequal-mass scattering. This gives the Regge behavior $u^{\alpha(s)}$ at $s = 0$ and in its neighborhood. Then a possibility is considered that a fixed pole contribution is completely eliminated by a counteracting Regge amplitude. It is shown that, if such an amplitude is added, the total Regge amplitude vanishes at $s = 0$. (auth)

**19007** CROSSING AND UNITARITY IN A MULTICHANNEL STATIC MODEL. II. Ehrhardt, P. O. G.; Fairlie, D. B. (Univ. of Durham, Eng.). J. Math. Phys. (N. Y.), 10: 339-41 (Feb. 1969).

Constraints on the solution of the unitarity equation for a two-channel scattering problem arising from the requirements of crossing for the inelastic amplitude are shown to imply the relations imposed by crossing under SU(2) for the elastic amplitudes in the limit of vanishing coupling to the inelastic channel. This result is extended to the three-channel case, where at least two distinct classes of internal symmetry crossing relations can exist: the unitarity equations alone simulate the SU(2) case, but not that associated with higher symmetry groups. (auth)

**19008** UNITARITY EQUATION AT HIGH ENERGY. Halliday, I. G.; Saunders, L. M. (Imperial Coll. of Science and Tech., London). Nuovo Cim., 60A: 115-30(Mar. 1, 1969).

It is shown that in terms of the Sudakov variables the high-energy form of the unitarity equation is exceedingly simple. The result is used to derive the multi-Regge model contribution to the imaginary part of the two-body elastic amplitude. It is argued self-consistently that this contribution need not break the Froissart bound. The Sudakov technique is also shown to give immediate calculations of the ladder diagrams in perturbation theory and of n-fold, two-particle s-channel iterations of t-channel Regge poles. The latter leads to a simple derivation of the properties of the associated Regge cuts. (auth)

**19009** S-MATRIX PERTURBATION METHOD. Kang, Kyungsik (Brown Univ., Providence). Contract AT(30-1)-2262. New Phys. (S. Korea), Suppl., 7: No. 2, 29-33(June 1968). (NYO-2262TA-169).

An exact solution of the shifts in bound-state energy and coupling constant due to a slight perturbation in the binding force is obtained within the framework of the N/D method. The first-order results are derived by making the determinantal approximation to the exact solution. It is also shown that the familiar Dashen–Frautschi result corresponds to making a further approximation to the unitarity cut integral. (auth)

**19010** TWO-BODY OFF-SHELL POTENTIAL SCATTERING. Warburton, A. E. A.; Stern, M. S. (Univ. of Hull, Eng.). Nuovo Cim., 60A: 131-59(Mar. 1, 1969).

A method is developed for the calculation of two-body scattering amplitudes for a wide class of local potentials, both on and off the energy shell. Padé approximants, ratios of polynomials in both the energy and the off-shell momenta, are obtained for the terms in Weinberg's separable expansion of the T-matrix, giving a simple representation of the matrix elements for all off-shell momenta, and energies throughout the complex plane. The approximants are exact for the Hulthén potential, and results are given for the Yukawa potential. (auth)

**19011** ASYMPTOTIC UNITARITY AND FIXED-ANGLE SCATTERING. Burkhardt, H. (Univ. of Birmingham, Eng. Univ. of California, Los Angeles). Nuovo Cim., 60A: 160-72 (Mar. 1, 1969).

The restrictions imposed by unitarity on the fixed-angle elastic amplitude at high energy are studied using new arguments, based on using unitarity directly without the partial-wave expansion. It is shown that the exponential decrease of cross section with center-of-mass energy, where the exponent is a convex function of angle, implies that contributions to the phase of the amplitude come only from intermediate states where all particles are in the diffraction regions of the initial or final directions. Taking into account the experimental absence of fluctuations in cross section, several simple models all suggest that the fixed-angle amplitudes must be asymptotically real, if the unitary bound is not to be exceeded. (auth)

**19012** INVERSION PROBLEM WITH SEPARABLE POTENTIALS. Mills, Robert L. (Ohio State Univ., Columbus); Reading, John F. J. Math. Phys. (N. Y.), 10: 321-31(Feb. 1969).

The problem of finding a potential, expressible as the sum of a finite number of separable terms, to fit a given phase shift at all energies is solved quite generally for nonrelativistic scattering within a single channel. The most general solution is found, and the necessary restrictions on the phase shift and the role of bound states are studied. The minimum number of separable terms needed to fit a given phase shift in a given channel is found to be determined, normally, by $1 + \max\{[\delta(x_2)/\pi] - [\delta(x_1)/\pi]\}$, $x_2 > x_1$ where $x_1$ and $x_2$ range through all positive energies, and $[y]$ is the largest integer less than or equal to $y$. The method differs from that of Kh. Chadan [Nuovo Cimento, 10: 892(1958); 47: 510(1967)] who has solved what is, in essence, the same problem, in that it involves spherical Bessel transforms throughout, rather than the use at each stage of a representation determined by the solution of a previous stage. (auth)

**19013** ON THE PROBLEM OF THE BOUND STATES IN THE FRAMEWORK OF THE PADE APPROXIMANTS. Caneschi, L.; Jengo, R. (CERN, Geneva). Nuovo Cim., 60A: 25-32 (Mar. 1, 1969).

It is suggested that the dependence of the poles of the Padé approximants on the masses of the external virtual particles for an off-mass-shell scattering amplitude may be used in order to improve, by means of a variational principle, the determination of the bound states. (auth)

**19014** THE APPLICATION OF REDUCTION FORMULAE IN ZACHARIASEN–THIRRING MODEL WITH TWO COUPLING CONSTANTS. Lukierski, J.; Turko, L. (Univ., Wroclaw). Bull. Acad. Pol. Sci., Ser. Sci. Math. Astron. Phys., 16: 905-9(1968).

It is shown that the reduction formula provides an elegant way of deriving the formula for the phase shift scattering. The exact two-point propagator is calculated for the model. The reduction formula is applied. The comparison of the result with the appropriate sum of Feynman graphs calculated on the ground of perturbation theory provides a consistency check for the validity of generalized LSZ asymptotic condition in the case of the Zachariasen–Thirring model with two coupling constants. (J.F.P.)

**19015** REGGE TRAJECTORIES FOR COULOMB NUCLEAR S-MATRIX. Shastry, C. S.; Satpathy, R. K. (Saha Inst. of Nuclear Physics, Calcutta). Nuovo Cim., 60B: 114-20(Mar. 11, 1969).

Calculations are performed to investigate the Columb effects in the "nuclear" part of the Coulomb nuclear S-matrix. The Regge trajectories for the pure nuclear S-matrix and Coulomb nuclear S-matrix are compared. The possible applications of these studies in analyzing scattering problems are discussed. (auth)

**19016** SPACE–TIME DESCRIPTION OF INELASTIC PROCESSES AT HIGH ENERGY. Andreev, I. V.; Dremin, I. M. (Lebedev Inst. of Physics, Moscow). Yadern. Fiz., 9: 176-9 (Jan. 1969). (In Russian).

An attempt is made to consider in an explicit form the space region and the effective interaction time for inelastic processes at high energy. In framework of the S-matrix theory for different models of multiple production an estimate is given for the effective space-time region where (the interaction proceeds). (auth)

**19017** POMERANCHUK TRAJECTORY AND UNIVERSALITY OF TRAJECTORIES. Chernyak, V. L. (Inst. of Mathematics and Computer Center, Novosibirsk, USSR). Yadern. Fiz., 9: 180-3(Jan. 1969). (In Russian).

A universality hypothesis for the vector and tensor trajectories is formulated. A self-consistent description of properties of the trajectories and of the observable particles is given. By means of a small number of parameters it is possible to achieve an agreement with the data available on the total $\pi N$, $KN$, and $NN$ cross sections and on the decays of the tensor mesons ($2^+ \to 0^- + 0^-$). Properties of the Pomeranchuk trajectory are discussed. (auth)

**19018** WEINBERG'S SEPARATION OF THE AMPLITUDE IN THE K-MATRIX FORMALISM. Mishima, Nobuhiko (State Univ. of New York, Buffalo). Phys. Rev., 177, 2505-11(Jan. 25, 1969).

The Weinberg method of obtaining a separable amplitude by the use of the eigenfunctions of the kernel of the Lippmann–Schwinger equation is given in the K-matrix formalism. This can be carried out in a way parallel to, but much simpler than, the formulation given previously in the T-matrix formalism. Relations between quantities in the K-matrix and T-matrix formalisms are obtained, and it is shown that the analytic extension into the complex energy plane is assured through these relations. Furthermore, it is shown that the formulations in the K-matrix formalism are very useful in applications to the composite-particle scattering problem. (auth)

**19019** APPLICATION OF ABSORPTIVE CORRECTIONS TO REGGE-POLE EXCHANGES. Ebel, M. E.; Moore, R. J. (Univ. of Wisconsin, Madison). Contract AT(11-1)-881. Phys. Rev., 177: 2470-2(Jan. 25, 1969). (COO-881-172).

The example of the box amplitude in the high-energy limit suggests that the off-shell contribution to iterated scattering amplitudes is important at high energies. The relevance of this to the application of absorptive corrections to Regge-pole exchanges is discussed. (auth)

**19020** DISCONTINUITIES OF KINEMATIC FACTORS AT ZERO MASSES AND RELATED PROBLEMS. Daboul, Jamil

(Univ. of California, San Diego, La Jolla). Phys. Rev., 177: 2375-89(Jan. 25, 1969).

It is explained why some kinematical factors are discontinuous when one of the masses vanishes. The kinematic factors for general reactions involving one massless particle are derived. The method can be easily extended to more than one massless particle. The crossing relations are used to rederive and generalize in a simple way the kinematical constraints at s = 0 recently obtained by Stack. A general expression is given for the determinant of the regularized crossing matrix and its applications are discussed. (auth)

**19021** BRANCH POINTS IN THE COMPLEX ANGULAR MOMENTUM PLANE AND HIGH-ENERGY BEHAVIOR OF SCATTERING AMPLITUDES. Yabuki, Haruichi (Kyoto Univ.). Phys. Rev., 177: 2209-17(Jan. 25, 1969).

The high-energy behavior of scattering amplitudes is investigated by analyzing the contribution from a certain class of Mandelstam branch points in the complex angular momentum plane. The branch point generated by n-Pomeranchon exchange is denoted symbolically by nP. It is shown that the totality of the contributions from the branch points of the type X + nP (n = 1, 2, . . .) gives an oscillatory behavior to scattering amplitudes at high energies, and that it results in a simple modification of the one-Regge-pole (X) contribution in the impact-parameter formalism. For the branch points of the type nX (n = 2, 3, . . .; X ≠ P), the concept of an effective trajectory is introduced. High-energy proton-proton scattering at 90° is explained by the effective trajectory generated by the branch points of the type (n – m) P′ + mω (n = 2, 3, . . .; m = 0, . . ., n). (auth)

**19022** CAUSALITY IN NONRELATIVISTIC QUANTUM SCATTERING. Nussenzveig, H. M. (Univ. of Rochester, N. Y.). Phys. Rev., 177: 1848-56(Jan. 25, 1969).

A new formulation of the causality condition, in terms of the total wave function at a finite distance from the scatterer, is given. This condition is employed to derive all known analytic properties of the scattering amplitude in both variables (energy and scattering angle or momentum transfer) for a scatterer of finite radius. It is shown that all the assumptions are valid in the particular case of scattering by a local potential. The relations between causality, Wigner's inequality, and completeness are discussed. (auth)

**19023** ALTERNATIVE CONSTRUCTIONS OF CROSSING-SYMMETRIC AMPLITUDES WITH REGGE BEHAVIOR. Virasoro, M. A. (Univ. of Wisconsin, Madison). Contract AT(11-1)-881. Phys. Rev., 177: 2309-11(Jan. 25, 1969). (COO–881-198).

A representation for the scattering amplitude that contains Regge behavior, crossing symmetry, and analyticity is discussed. It is shown that it provides a different ghost-eliminating mechanism (the Mandelstam–Wang one) from that given by Veneziano's proposal. Furthermore, it does not restrict the external masses, but reduces to Veneziano's formula when $\alpha(s) + \alpha(t) + \alpha(u)$ equals a particular integer that depends on the reaction. Several examples are discussed. The behavior of the Regge residue $\beta_{\rho\pi\pi}(t)$ at $\alpha_\rho(t) = 0$ is proposed as a test that distinguishes the two representations. (auth)

## Particle Accelerators

*Refer also to abstracts 17792, 17801, 17823, 17848, 18423, 18807, 19200, 19253, and 19254.*

**19024** (AD–672932) NONRELATIVISTIC NUCLEAR REACTION KINEMATIC CROSSOVER ANGLES. Warshaw, Stephen I. (Illinois Univ., Urbana. Dept. of Physics). July 1968. Contract N00014-67-A-0305. 11p. CFSTI.

A nonrelativistic expression relating the bombarding energy to the laboratory angle at which the energies of reaction products from two dissimilar nuclear reactions coincide is derived and discussed. Applications to accelerator beam energy measurement, detector angular calibration, and nuclear reaction experiment planning are considered. (auth) (USGRDR)

**19025** (AD–674750) ENERGY DISTRIBUTION OF POSITIVE IONS EXTRACTED FROM A HOT-CATHODE GAS DISCHARGE ION SOURCE. Research Communication No. 65. Theard, Lowell P. (Douglas Aircraft Co., Inc., Huntington Beach, Calif. Advanced Research Lab.). June 1968. 30p. (DAC–5199). CFSTI.

An electrostatic parallel-plate energy analyzer was used for measuring the energy distribution of Ar (+) ions in a beam extracted from a non-magnetic hot-cathode gas discharge ion source under various conditions of source pressure, anode voltage, and anode current. A large number of energy distribution curves were obtained as X-Y recordings. The curve shape depends upon source conditions, though not strongly when the pressure is greater than 0.003 torr with an anode voltage above 50V (for argon) and an anode current of at least 200 mA. When conditions are optimum, the ion energy distribution curve is a narrow peak with a tail that gradually diminishes toward lower energies over an interval of approximately 30 eV. The actual value of the optimum full-width at half-maximum was found to be 1.1 eV by extrapolation to zero beam energy. The shape of the curve is such that more than 81 percent of the beam ions have energies within a 10-eV interval. The source can be used to increase beam currents greatly in certain types of magnetic deflection mass spectrometers without extreme loss of mass resolution due to ion beam energy spread. (auth)(USGRDR)

**19026** (ANU-P–414) A METHOD OF MEASURING (p,n) THRESHOLDS FOR THE CALIBRATION OF BEAM ANALYZING SYSTEMS. Morris, J. M.; Ophel, T. R. (Australian National Univ., Canberra. Research School of Physical Sciences). [nd]. 4p. Dep.

The design of a radiation target chamber for measuring (p,n) reaction threshold energies for calibration of beam analyzing systems is described. Results of the measurements of boron-11 (p,n) and carbon-13 (p,n) thresholds are presented. (W.H.K.)

**19027** (BNL–13348) NOTE ON THE DISPERSION RELATION OF PERIODIC CAVITY CHAINS WITH TWO COUPLED PASSBANDS. Nishikawa, T. (Brookhaven National Lab., Upton, N. Y.). Dec. 1968. 29p. Dep. CFSTI.

An elementary consideration of the general behavior of two coupled oscillating systems is presented and the relation between the general behavior and the dispersion relation for the ideal cavity chain with two coupled passbands is shown. Some practical problems are considered which may cause the analyses based on the idealized model to be inapplicable. Also, the effects of symmetry mixing, nonuniform cell distributions, and wall losses are discussed. (auth)

**19028** (BNL–50120(Pt.1)) PROCEEDINGS OF THE 1968 PROTON LINEAR ACCELERATOR CONFERENCE. PART 1. (Brookhaven National Lab., Upton, N. Y.). 1968. 444p. (CONF-680515–(Pt.1)). Dep. CFSTI.

From Conference on Proton Linear Accelerators, Upton, N. Y.

Separate abstracts were prepared for twenty-six of the forty-five papers presented. Nineteen papers were previously included in NSA. For abstract numbers of these papers see CONF-680515 in the Report Number Index. (B.G.D.)

*For abstracts of individual papers see: 19029–19053 and 19580.*

**19029** (BNL–50120(Pt.1), pp 30-40) MECHANICAL DESIGN FEATURES OF THE NAL 200-MeV LINAC INJECTOR. O'Meara, J.; Palmer, M. (National Accelerator Lab., Batavia, Ill.).

The design characteristics of a 200 MeV linear accelerator for use as an injector for the NAL 200-GeV synchrotron are described. It is noted that the linac is similar to the linac being constructed at Brookhaven National Laboratory. The design characteristics discussed are the drift tubes, alignment fixtures, and rf cavity. (B.G.D.)

**19030** (BNL–50120(Pt.1), pp 41-51) ACCELERATOR MAGNET DEVELOPMENT AT CRNL. Harvey, A.; Wolfe, W. A.; Blackstein, F. P.; Otter, A. J. (Atomic Energy of Canada Ltd., Chalk River (Ontario). Chalk River Nuclear Labs.).

Two unique requirements for the magnets of the Intense Neutron Generator are discussed. These are that they must be of high quality, to spill as small a fraction of the proton beam current and that they must be able to withstand a higher radiation dose from the particles which are spilled. The magnet requirements for the Alvarez section and coupled cavity section are also discussed. (B.G.D.)

**19031** (BNL–50120(Pt.1), pp 52-9) HIGH GRADIENT MAGNETIC DRIFT TUBE QUADRUPOLES. Main, Robert M.; Halbach, Klaus; Kennedy, Patrick; Yourd, Roland; Watanabe, Albert; Kolody, Daniel (California Univ., Berkeley. Lawrence Radiation Lab.).

The high-gradient magnetic drift tube quadrupoles for the Berkeley heavy-ion accelerator (Hilac) are discussed. Topics include tape coils, coil fabrication, yoke-pole design, yoke-pole fabrication, drift-tube design, and magnet performance. (B.G.D.)

**19032** (BNL–50120(Pt.1), pp 60-7) NEW TECHNIQUE FOR HIGH PRECISION ALIGNMENT OF LINEAR ACCELERATORS. Betz, Hans D. (Kansas State Univ., Manhattan).

A new alignment and surveillance technique of high accuracy is described. Utilizing asymmetrical effects produced in the light distribution of a laser beam, this new method shows remarkable advantages: any number of object-points can be placed on a straight line and displacements of 0.01 mm, for example, are detectable in

distances from zero to several kilometers, provided that the disturbing influences of turbulence and refraction in the atmosphere are eliminated. The setup is very simple, and all targets representing object-points are identical. Therefore, the equipment to be used, including the detection unit, is independent of all distances involved. The alignment can be done simultaneously in two dimensions, both visually and fully automated. Special applications to linear accelerators with lengths up to several kilometers will be discussed and compared with conventional and existing alignment techniques. Limitations and distorting effects will also be considered. (auth)

**19033** (BNL-50120(Pt.1), pp 68-75) R. F. SOURCES DEVELOPMENT AT C. R. N. L. Waterton, P. J. (Atomic Energy of Canada Ltd., Chalk River (Ontario)).

The size and efficiency requirements of the rf sources for the ING linear accelerator are discussed. (B.G.D.)

**19034** (BNL-50120(Pt.1), pp 94-100) NEW PULSE MODULATOR FOR THE ZERO GRADIENT SYNCHROTRON LINAC. Abraham, J.; Sesol, N. (Argonne National Lab., Ill.).

Design and construction of a 15 MW pulse modulator has begun at Argonne National Laboratory to replace the unit in present use. The unit, which employs a single switch tube, is capable of regulation during 50-200 μsec beam pulses in a regulating loop which includes the entire linac. A dual fast-fault protection system incorporates clamping of the switch tube and a backup system which terminates the drive signal during load faults. Design data and operating characteristics will be discussed. (auth)

**19035** (BNL-50120(Pt.1), pp 108-13) TRANSIENT BEAM LOADING IN STANDING WAVE LINACS. Lee, M. J. (Brookhaven National Lab., Upton, N. Y.).

Steady-state cavity excitation and beam loading in standing wave linacs have been analyzed by a number of authors. More recently, analysis included transient behavior of these phenomena. In all of the analyses to date, constant beam velocity and identical cavity cells are assumed. These assumptions, however, become less valid for low energy linac cavities such as those at the beginning of the Conversion linac. In the present paper the amplitude of the beam induced field is calculated. The analysis takes into account the changes in the beam velocity and cavity cell length along the linac. (auth)

**19036** (BNL-50120(Pt.1), pp 168-74) EMITTANCE MEASUREMENT AT THE CERN PS LINAC WITH AN ON-LINE COMPUTER. Tallgren, U.; Kracht, U.; van der Schueren, A. (European Organization for Nuclear Research, Geneva (Switzerland)).

The emittance measurement equipment at the CERN PS Linac has been connected to an on-line computer (IBM 1800). Four digitalized parameter values, six limit numbers and a status word are fed over a fast multiplexer system 200 m to the computer. The advancement of the measurement gear is under control of the computer. A typewriter at the linac gives a line by line print-out of elementary emittance currents giving by their positions on the print-out the shape of the phase space area and the current distribution inside it. Ten error conditions can at present be recognized by the computer program. Error messages are displayed on a TV-monitor or printed out on the typewriter. Advantages gained from the on-line operation with the computer are less operator fatigue and possibility to follow immediately the evolution of the measurement. (auth)

**19037** (BNL-50120(Pt.1), pp 190-7) NONDESTRUCTIVE LINAC BEAM DENSITY PROFILE MONITOR. DeLuca, William H.; Shea, Michael F. (Argonne National Lab., Ill.).

Properties of the beam, emerging from proton linear accelerators, are normally measured with the aid of destructive diagnostic equipment such as slits and Faraday cups. A nondestructive beam density profile monitor which has been designed and built for use in the Argonne National Laboratory 50 MeV proton lines is described. (auth)

**19038** (BNL-50120(Pt.1), pp 198-219) BEAM DIAGNOSTICS OF THE 50 MeV PROTON LINEAR ACCELERATOR OF THE ARGONNE ZERO GRADIENT SYNCHROTRON. Abdelaziz, M. E.; Perry, R. (Argonne National Lab., Ill.).

Since the performance and stability of the Zero Gradient Synchrotron (ZGS) are critically dependent on the linac beam behavior, it is necessary to study the properties of the 50-MeV proton linac beam for the ultimate purpose of its control by the CDC 924 computer. The first property examined was beam position monitoring. This included analysis of calculations of induced loop voltage, experimental characteristics of loop position detectors and effects of linac parameters on beam position. The second property was beam emittance and a method for performing these measurements is described. (B.G.D.)

**19039** (BNL-50120(Pt.1), pp 220-7) PHASE SHIFT OF BEAM BUNCHES AS A FUNCTION OF LINAC ACCELERATING GRADIENT. Perry, Rolland; Abraham, Joseph (Argonne National Lab., Ill.).

It was shown in an earlier report that an unexpectedly large phase shift occurs in beam bunches from the ANL 50 MeV, 200 MHz linac when the rf gradient is allowed to fall due to beam loading, and that this phase shift does not occur when the gradient is held constant. No corresponding shift of phase of the rf fields in the linac cavity were observed; and, since there was a reduction of beam current accompanying the phase shift and the gradient reduction, it was not made clear by deliberately reducing the current whether the current or the rf gradient is the independent variable since the two were interdependent. There was also some question regarding the possibility of phase shift of the rf field on axis relative to the field at the cavity wall. Further measurements were made in an attempt to resolve some of these questions. (auth)

**19040** (BNL-50120(Pt.1), pp 240-50) THE NEW SATURNE INJECTOR STATUS REPORT ON THE 750 keV PREINJECTOR. Faure, J. (Commissariat a l'Energie Atomique, Saclay (France). Centre d'Etudes Nucleaires).

A report on the new 20-MeV linac 750 keV preinjector named Amalthee is presented. This preinjector provides a 100 aM proton pulsed beam at the linac entrance. The pulse duration is 200 μs and the beam emittance value at the output of the preinjector itself is, so far, $2.5 \times 10^{-6}$ m-rad (normalized value). First, the preinjector is described. Then the results of emittance measurements are given and discussed. Finally, the ion optics between Amalthee and linac are examined. (auth)

**19041** (BNL-50120(Pt.1), pp 269-92) PRELIMINARY STUDY OF A HIGHER ENERGY PRE-INJECTOR FOR THE CERN PS. Huguenin, J.; Tallgren, U.; Weiss, M. (European Organization for Nuclear Research, Geneva (Switzerland)).

The improvement program of the CERN PS linac foresees a possible reconstruction of the first tank. In connection with this we felt it interesting to study the influence of an increase in the preinjector energy. The results from a first study presented here indicate interesting advantages to be gained, particularly if the preinjector energy could be pushed up drastically, e.g., by a factor 4-5. Technological aspects will put a limit to such a change and a fresh look at the problem connected with the accelerating tube, H.T. supply and the ion source has been made. Lay-out, reliability and operational aspects were also discussed. It was concluded that it would be worth while to carry out a more detailed study of the feasibility of a higher energy pre-injector in view of the potential advantages to be gained for the linac beam. (auth)

**19042** (BNL-50120(Pt.1), pp 306-16) COMPARATIVE STUDY OF DRIFTING ARC AND EXTENDED STATIONARY ARC DUOPLASMATRONS. Fasolo, John A. (Argonne National Lab., Ill.).

A drifting arc duoplasmatron used in previous studies has been converted into an extended stationary arc duoplasmatron for use in a comparative study of these two basically different source types. To facilitate comparison, the Pierce extraction geometry of the drifting arc source has been retained. Some results of this study will be presented and discussed. (auth)

**19043** (BNL-50120(Pt.1), pp 317-27) BUNCHING. Lapostolle, P. M. (European Organization for Nuclear Research, Geneva (Switzerland)).

After having reviewed the various performances which can be attributed to a buncher and some of the devices which have been used so far or studied in the absence of space charge, the problem of bunching at high intensity is considered and various types of attempts are described with some numerical results given. (auth)

**19044** (BNL-50120(Pt.1), pp 346-52) LONGITUDINAL SPACE-CHARGE EFFECTS IN BUNCHERS. Lee-Whiting, G. E.; Ormrod, J. H. (Atomic Energy of Canada Ltd., Chalk River (Ontario). Chalk River Nuclear Labs.).

Calculators of space-charge effects in the early stages of proton linacs have usually made some arbitrary assumption about the distribution of charge density in the bunch. It ought to be possible to make an estimate of the charge density by following the motion of the protons from the injector through the buncher to the accelerator entrance. Two different attempts to perform such a calculation are described. (B.G.D.)

**19045** (BNL-50120(Pt.1), pp 353-6) PHASE SPACE ACCEPTANCE OF A QUADRUPOLE DOUBLET ANALYTIC EXPRESSIONS AND NUMERICAL RESULTS. Regenstreif, E. (Rennes Univ. (France). Faculte des Sciences).

The phase space acceptance of a quadrupole doublet in the focusing plane and in the defocusing plane was calculated. (B.G.D.)

**19046** (BNL-50120(Pt.1), pp 357-63) ACCEPTANCE CALCULATIONS FOR ACCELERATOR BEAM LINES. Blackstein, F. P. (Atomic Energy of Canada Ltd., Chalk River (Ontario)).

A computer program to determine the first order phase plane acceptance of accelerator beam lines is described. It is based on an iterative technique for scanning the phase space and computing time is reduced by an order of magnitude when compared to similar methods employing an ordered scan in rectangular coordinates. An example system is analyzed; acceptance polygons are presented and the energy dependence of the beam line acceptance is computed. (auth)

**19047** (BNL-50120(Pt.1), pp 389-94) MULTIMODE AND RESONANCE EFFECTS IN TRANSVERSE BEAM BLOW-UP. Gluckstern, R. L.; Prasad, S. C. (Massachusetts Univ., Amherst).

The usual estimate of the current at which transverse beam blow-up occurs is made under the assumption of a single transverse mode not in resonance with the beam frequency. For a single mode the starting current decreases by less than a factor of two at resonance. The case of several modes was numerically treated, using an eigen-mode method and considerable structure was found in the dependence of the starting current on the frequency of the transverse band. Specifically reductions were found of up to a factor two as the frequencies of the main mode and the adjacent modes pass through resonance with the beam frequency. Furthermore, there are additional variations exactly midway between these resonances. Typical numerical results of this eigenmode method are presented. In addition, the particular features of each anomaly are derived from an analysis of which modes are most important at each frequency. Our analysis and results once again confirm the fact that the starting current never decreases below half of the value for a single non-resonant mode. (auth)

**19048** (BNL-50120(Pt.1), pp 395-9) UNIFIED THEORY ON BEAM DYNAMICS IN PROTON LINACS. Nishikawa, T. (Tokyo Univ. (Japan)).

Using the Vlasov equation, the longitudinal and the transverse motions in proton linacs in a six-dimensional phase space were discussed. Although some simplified assumptions were made, a unified theory is derived for the physical analysis on space-charge effects, longitudinal and transverse coupling effects, and other high intensity effects. In particular, it is pointed out that the coupling between the longitudinal and the transverse motions will be considerably enhanced through the collective motion of the particle assembly. (auth)

**19049** (BNL-50120(Pt.1), pp 400-8) ELECTROMAGNETIC FIELD OF TRAVELING CHARGE IN BEAM DUCT. Hirakawa, Hiromasa (Tokyo Univ. (Japan). Dept. of Physics).

The space charge field in a beam duct is expanded in a power series of a parameter $\alpha$ which is proportional to the square root of wall resistivity. The leading term in the expansion is the field in a duct of perfect conductor. The self-defocusing force of the space charge is modified by the induced charge on the wall. Generally, the induced charge gives a longitudinal focusing force, while it invariably is accompanied by transverse defocusing forces (Earnshaw's theorem). Besides these, the whole space charge is attracted toward the wall when the charge distribution has no symmetry around the axis. This contributes to the orbit distortion and the instability of the orbit with respect to transverse displacements. The second term in the expansion gives a decelerating force for the charge, which makes up for the energy dissipation in the duct wall, together with transverse forces, which are responsible for resistive instabilities. In the following, the field of traveling charge in a cylindrical duct of perfect conductor is examined. The expansion of the field in the parameter $\alpha$ and the effects of the wall resistivity are discussed. (auth)

**19050** (BNL-50120(Pt.1), pp 409-15) LONGITUDINAL AND TRANSVERSE T AND S TRANSIT TIME COEFFICIENTS. Schnizer, B. (European Organization for Nuclear Research, Geneva (Switzerland)).

Difference equations describing the motion of a proton through an accelerating gap have been given by Lapostolle at the Frascati Conference (1965) and by the author (Washington Conference, 1967). The dynamical coefficients contained in them are discussed. There are two types, called T- and S-coefficients. T-coefficients belong to motion across the whole gap and have a simple form (transit time factor times a modified Bessel function). Difference equations through the first half of the gap needed to determine the mid-gap values of the particle coordinates, involve in addition S-coefficients. Exact expressions (series expansions) for the latter are given here assuming that the Fourier coefficients of $E_z(r = a)$, the longitudinal field along the gap circumference, are known. Approximations for the S-coefficients are discussed. Corrected Tables of non-relativistic and relativistic difference equations are given. (auth)

**19051** (BNL-50120(Pt.1), pp 416-25) REDUCTION OF ENERGY SPREAD ON THE RUTHERFORD LABORATORY P. L. A. Carne, A.; Dickson, J. M.; Norcliffe, S.; Webb, J. S. (Rutherford High Energy Lab., Chilton (England)); Batchelor, K. (Brookhaven National Lab., Upton, N. Y.).

Two methods for reducing the energy spread on the Rutherford Laboratory proton linear accelerator are discussed. The first consists of shaping the fields along the linac to control the energy acceptance along the machine. The second consists of using a debuncher. (B.G.D.)

**19052** (BNL-50120(Pt.1), pp 426-9) ENERGY MODULATED BEAM INJECTION AT THE ARGONNE ZERO GRADIENT SYNCHROTRON. Myers, W. (Argonne National Lab., Ill.).

The methods used and the results obtained from Zero Gradient Synchrotron machine studies in which the energy modulation technique was applied to both fast and slow ring rf turn-on programs are discussed. (auth)

**19053** (BNL-50120(Pt.1), pp 430-2) CALCULATION OF THE DEPOLARIZATION OF AN INITIALLY POLARIZED BEAM IN THE LOS ALAMOS LINAC. Mobley, Richard M. (Yale Univ., New Haven, Conn.). Contract AT(30-1)-2726.

A polarized proton beam is planned for the Los Alamos Meson Facility. A numerical calculation of the spin motion for a sufficient number of orbits was performed to obtain a reliable evaluation of the amount of depolarization to be expected in the linac. A major advantage of linacs in the field of polarized beams is the ability to propagate the beam with any orientation of the polarization vector. Thus it is possible to provide a longitudinally polarized beam at a target area off the main beam line by tilting the polarization vector at injection to compensate for the change in orientation occurring at the bending magnet. For this reason skewed orientations were used as well as transverse and longitudinal orientations in the calculations. (auth)

**19054** (BNL-50120(Pt.2)) PROCEEDINGS OF THE 1968 PROTON LINEAR ACCELERATOR CONFERENCE. PART 2. (Brookhaven National Lab., Upton, N. Y.). 1968. 362p. (CONF-680515-(Pt.2)). Dep. CFSTI.

From Conference on Proton Linear Accelerators, Upton, N. Y.

Separate abstracts were prepared for twenty-one of the thirty-three papers presented. Eight papers were previously included in NSA. For abstract numbers of these papers see CONF-680515 in the report number index. (B.G.D.)

*For abstracts of individual papers see: 18575 and 19055-19076.*

**19055** (BNL-50120(Pt.2), pp 445-56) NEW INTERPRETATION OF STRUCTURE COMPENSATION. Dome, G.; Lapostolle, P. (European Organization for Nuclear Research, Geneva (Switzerland)).

In a periodic structure, there are always two basic waves for each frequency. Inside a passband, these basic waves are the two travelling waves which can propagate in both directions down the structure. At the edge of a passband (0 or $\pi$ mode), the two travelling waves become identical, and another basic solution must be found. This second solution, instead of being periodic, varies linearly along the structure. One of the basic waves is thus periodic, while the second one is nonperiodic, and they have opposite parities with respect to a symmetry plane of the structure. If the adjacent edges of two neighboring passbands are considered, the two periodic waves at these two cut-off frequencies have also different parities. When the structure is progressively deformed until the two adjacent cut-off frequencies merge, that is when the structure is being compensated, the nonperiodic wave at one frequency tends towards the periodic wave at the other frequency: therefore, in a compensated structure, both basic waves are periodic along the structure at the crossing point of the two passbands. Assume several cells of a terminated structure are detuned in such a way that the overall resonant frequency remains equal to the cut-off frequency of the perfect structure; reactive power flows out of the detuned cells, and such a non-zero flux can arise only from a combination of the two basic waves at the given frequency. The field between two detuned cells thus varies linearly in general, whereas it remains periodic in a compensated structure. Finally, measured field variations along the axis of locally compensated non-uniform Alvarez structures are compared with theoretical estimates obtained by matching the maximum current on the outer wall of two adjacent Alvarez cells. (auth)

**19056** (BNL-50120(Pt.2), pp 457-70) TRIPERIODIC STRUCTURE. Epsztein, B.; Tran Duc Tien (Compagnie Generale de Telegraphie Sans Fil, Orsay (France)).

A number of alternating periodic structures have been described which operate with a $\pi/2$ phase shift between adjacent cavities, simulating a $\pi$ mode configuration while alternate cavities remain empty. It is shown that similar properties can be obtained with a

structure operating with a $2\pi/3$ phase shift. The basic cell, made of three cavities, is one wavelength long. If correct terminating conditions are satisfied, a standing wave pattern can be set up which simulates the $\pi$ mode field in two cavities, the third being empty. Two cases are being considered: 1) An iris structure where the empty cavities have a reduced length with respect to the others. Calculations and measurements show that the impedance is improved with respect to the corresponding $\pi/2$ structure, due to the fact that there is only one empty cell per wavelength instead of two, while other electrical properties remain unchanged. 2) A drift tube structure is also investigated. The coupling cavities are so designed as to prevent their direct excitation by the beam. (auth)

**19057** (BNL-50120(Pt.2), pp 471-4) ANALYSIS OF EQUIVALENT CIRCUITS FOR LINAC TANKS. Lee-Whiting, G. E. (Atomic Energy of Canada Ltd., Chalk River (Ontario). Chalk River Nuclear Labs.).

Two chains of N inductance-capacitance-resistance loops having inductive coupling (with coupling constant k) between nearest neighbors are described. Chain A is terminated with half loops, chain B with full loops. The resonant frequency, $\omega_0$, and the quality factor, Q, are the same for all loops in both chains. Such chains are useful in studying the response and the sensitivity to error of tanks of magnetically coupled cavities of the type that might be used in an 805 Mhz standing-wave proton linac. Work at Los Alamos has shown that for many of its properties a linac tank may be represented by an equivalent circuit of the type shown. An analysis is presented of the steady-state response of both chains to a driving EMF, shown in the $p^{th}$ loop in the figure. The useful insensitivity of the loop currents to parameter error in the $\pi/2$ mode is shown to extend to the second order of perturbation theory. (B.G.D.)

**19058** (BNL-50120(Pt.2), pp 475-98) MEASUREMENTS OF FIELD STABILITY AGAINST PERTURBATIONS IN NON-UNIFORM LINAC STRUCTURES. Dome, G.; White, I. (European Organization for Nuclear Research, Geneva (Switzerland)).

Scale models of tank 1 (0.75-5 MeV) and tank 2 (10-30 MeV) have been used to investigate the stability of the axial electric field against individual cell tuning errors. As reported previously, a compensated structure for tank 1 consists of two stems at 45° on each drift tube, alternating at 180° from one drift tube to the next. The axial electric field is shown to be unaffected by a perturbation produced by a metallic rod parallel to the axis and placed at one end of the tank. Insensitivity of the field to perturbations has also been achieved experimentally with two stems at 150° on each drift tube, all stems being parallel from one drift tube to the next. The frequency shift of the Alvarez zero-mode due to the stems is larger than predicted by theory in tank 1. A compensated structure for tank 2 is the cross-bar with an appropriate stem diameter. When the stem diameter is kept constant throughout the tank, compensation is achieved only on the average and the axial field is strongly affected in the region where the perturbation is introduced. This effect can be reduced by compensating locally small groups of drift tubes; a good stability of the field is then obtained. The frequency shift of the Alvarez zero-mode due to the stems is close to the theoretical value in tank 2. Finally, a full scale 200 MHz cross-bar cell designed to accelerate protons at 140 MeV in the $\pi$ mode (defined as the phase-shift over a complete geometrical period) of the stem passband has been tested at a power level of 435 kW, which would produce an acceleration rate of 4 MeV/m at $\varphi_s = 0$, with an average axial field of 4.6 MV/m. (auth)

**19059** (BNL-50120(Pt.2), pp 499-511) FIELD PERTURBATIONS IN THE POST COUPLED DRIFT TUBE LINAC. Schneider, E. J.; Swenson, D. A. (Los Alamos Scientific Lab., N. Mex.).

Post coupler excitations have been shown to depend on tuning errors and power losses as predicted by the coupled resonator analysis. It was necessary to resort to very large tuning errors in order to produce measurable transverse fields on the axis of the linac. Tuning errors in an actual linac will certainly be 100 to 1000 times smaller than the tuning errors used here. The largest transverse field measured here ($\gamma = 6°$), when reduced by a factor of 100, would produce a transverse impulse that is very small compared to the radial impulse received by the average particle on crossing the gap. The quadrupole focusing system can easily counteract transverse fields of these magnitudes. (auth)

**19060** (BNL-50120(Pt.2), pp 512-22) IMPROVED METHOD FOR CALCULATING PROTON LINAC CAVITIES. Martini, M.; Warner, D. J. (European Organization for Nuclear Research, Geneva (Switzerland)).

An improved method for calculating the electromagnetic fields in a linac cavity of Alvarez type is presented. The solution of a finite difference form of the wave equation is obtained by the combined use of analytical formulae and the point successive over-relaxation (SOR) technique. By limiting the application of the numerical approach to the axial region of the linac cell where the complicated shape of boundary renders it unavoidable and in using analytical expansions elsewhere, an improved precision is obtained in a relatively short computer time. This precision is tested by comparison of the results obtained with those of other authors and by computing for each case a normalization factor which proves to be a sensitive check parameter. A Fortran program, CLAS (CERN Linear Accelerator Structures), capable of treating cavities with rotational symmetry and a general drift-tube profile, is described. A brief account of the theory of the method used and the main features of the CLAS program is also presented together with some recent results. (auth)

**19061** (BNL-50120(Pt.2), pp 533-6) LINAC CAVITY FIELD CALCULATIONS. Lee-Whiting, G. E. (Atomic Energy of Canada Ltd., Chalk River (Ontario). Chalk River Nuclear Labs.).

A review of previous reports on calculations of fields in linac cells indicated that difficulties arose with Alvarez-type cells, especially at lower values of $\beta$. Convergence becomes slower as $\beta$ is decreased, and there is some doubt about the accuracy of the results. Three devices for improving the calculation are discussed. They are directed toward decreasing the number of mesh points, improving the starting values for the relaxation, and increasing the speed of convergence of the frequency-iteration. (auth)

**19062** (BNL-50120(Pt.2), pp 543-56) MODEL CAVITY STUDIES FOR TANK DESIGN AND ON TANK FABRICATION. Baba, H.; Hirakawa, H.; Nishikawa, T.; Okumura, S.; Tanaka, J.; Tao, Y. (Tokyo Univ. (Japan)).

The design and fabrication of the first tank of the accelerating structure of an injector linac, in which protons are accelerated from 0.75 to 10 MeV, are discussed. The design study was based on data from MURA linac cavity calculations. (B.G.D.)

**19063** (BNL-50120(Pt.2), pp 557-64) STUDIES OF A SLOTTED IRIS STRUCTURE (DISPERSION CURVE, COUPLING FLATNESS, AND ELECTRON ANALOG EXPERIMENT). Eschelbacher, H.; Kuntze, M.; Schinzel, D.; Vetter, J. (Technische Hochschule, Karlsruhe (West Germany). Institut fuer Experimentelle Kernphysik).

The results of studies on bi-periodic slotted-ins structures for superconducting linear accelerators are presented. The main goal of the studies was to arrive at simultaneously high shunt impedance and high group velocity for a structure that can be plated with a superconducting layer. (B.G.D.)

**19064** (BNL-50120(Pt.2), pp 579-82) FIELD STABILIZATION IN PERIODIC SYSTEMS. Carter, D. (San Jose State Coll., Calif.).

Stabilization of periodic fields has been described together with a measure of such stabilization. Dispersion relationships and fields have been expressed for stabilized cavities. (auth)

**19065** (BNL-50120(Pt.2), pp 600-5) FUTURE FACTORY TYPE ACCELERATORS. Lewis, W. Bennett (Atomic Energy of Canada Ltd., Chalk River (Ontario)).

The design characteristics of various types of accelerators for use in an accelerator-assisted thermal neutron reactor system for economic production of neutrons are examined. (B.G.D.)

**19066** (BNL-50120(Pt.2), pp 608-21) STATUS OF THE INTENSE NEUTRON GENERATOR STUDY PROGRAMME. Tunnicliffe, P. R.; Ward, A. G. (Atomic Energy of Canada Ltd., Chalk River (Ontario). Chalk River Nuclear Labs.).

The status of AECL studies of the Intense Neutron Generator are summarized. ING is primarily a research instrument for the production of neutrons and mesons and is intended as the focal point of a many-sided research institute. A thermal neutron flux of $10^{16}$ n/cm$^2$·sec at the inner end of several beam tubes, high flux irradiation facilities, a saleable output of neutron produced isotopes, and a meson factory are highlights of this project. The primary neutron source, ~$10^{19}$/sec, would be generated by bombarding a lead-bismuth target with a continuous 65 mA beam of 1 GeV protons. (auth)

**19067** (BNL-50120(Pt.2), pp 626-34) A 3 MeV EXPERIMENTAL PROTON LINAC: DESIGN, CONSTRUCTION, AND PROPOSED EXPERIMENTS. Boltezar, E.; Malthouse, H. F.; Warner, D. J. (European Organization for Nuclear Research, Geneva (Switzerland)).

The design characteristics, construction, and proposed experiments of an experimental 3-MeV proton linear accelerator are discussed. The linac was proposed as a research facility eventually leading to an improved proton injector design having more protons per main machine pulse and better quality, i.e., reduced emittance. (B.G.D.)

**19068** (BNL-50120(Pt.2), pp 660-72) NEW SATURNE INJECTOR STATUS REPORT ON THE 20 MeV LINAC. Lefebvre,

JM.; Prome, M. (Commissariat a l'Energie Atomique, Saclay (France). Centre d'Etudes Nucleaires).

The proton linear accelerator, new injector for the Saturne synchrotron is an Alvarez structure, with a final energy of 20 to 20.6 MeV, and an input energy of 750 keV. The current requirements are 20 mA for a 625 μs impulsion time, rf pulse being 1 ms long. Maximum repetition rate is 1 Hz. The linac is now completely assembled; all main equipments are either ready to be used or being checked. Details are given on some particular aspects of this linear accelerator: technology, accelerating cavity, rf power supply and expected beam behavior. (auth)

**19069** (BNL-50120(Pt.2), pp 694-705) CERN-PS 50 MeV LINAC PROGRESS REPORT. Taylor, C. S.; Huguenin, J.; Block, F.; Chiari, F.; Tetu, P. (European Organization for Nuclear Research, Geneva (Switzerland)).

The high-gradient pre-injector (Ē = 4.5 MV/m) has been operating with the 50 MeV linac and the PS for a period of 2 years. The operational behavior of the ion source and accelerating tube are described. The behavior of the beam in the 50 MeV accelerator is then discussed in the light of recent experiments. Finally a brief account is given of the state of beam-loading compensation, and of plans for the future compensation of long beam pulses required by the PS Improvement Programme. (auth)

**19070** (BNL-50120(Pt.2), pp 706-12) REPORT ON THE ITEP 24.6 MeV AND SERPUKHOV 100 MeV LINACS. Taylor, C. S. (European Organization for Nuclear Research, Geneva (Switzerland)).

In April 1967, the 24.6 MeV proton linac injector of the Moscow 7 GeV PS produced 130 mA beam pulses after a few months of tuning-up. In February 1968, the 100 MeV injector of the Serpukhov 70 GeV PS also produced a high intensity beam (100 mA) after only 6 months of adjustment and trimming. Some of the details of these machines as given by Professor Kapchinskij during a visit to CERN in Feb. 1968, together with some information gathered by the author during a visit to these machines in Nov. 1967, are reported. (auth)

**19071** (BNL-50120(Pt.2), pp 735-44) STUDY OF A VARIABLE ENERGY HEAVY ION LINEAR ACCELERATOR. Schmelzer, Ch. (Heidelberg Univ. (West Germany). Institut fuer Angewandte Physik).

After a review of problems typical for heavy ion acceleration, plans for a variable energy heavy ion linear accelerator are discussed. Energy variation is obtained in the last section of the accelerator by adjustable excitation of the individual, equidistant gaps. For uranium ions the accelerator will cover a range from 2 to 9 MeV/AMU. (auth)

**19072** (BNL-50120(Pt.2), pp 745-54) ELECTRIC QUADRUPOLE FOCUSING IN LINEAR ION ACCELERATORS. Blasche, K.; Friehmelt, R.; Kaspar, K.; Schmelzer, Ch.; Wolfangel, U. (Heidelberg Univ. (West Germany). Institut fuer Angewandte Physik).

The focusing in the first sections of heavy ion linear accelerators ($\beta = 0.005$ to 0.04) may be achieved without the use of grids by employing electric quadrupole lenses. The focusing voltage required can be technically realized and would not exceed ±15 kV in the Manchester heavy ion injector linac. Using a low energy proton model (49 keV), the current yield and radial acceptance of the electric quadrupole focusing system have been studied. The experimental results are very interesting: the current yield is as high as 34% for the 24 drift-tube linac, and it rises to more than 60% when a buncher is used. A radial acceptance of 80 cm · mrad is measured. To the first order, the theory is identical for both electric and magnetic fields. In the second order, the focusing is different, since the electric lenses modify the particle energy due to the fringing fields. Computational results concerning the field gradients and the radial acceptance including coupling effects are the bases for the choice of parameters of a heavy ion linac. (auth)

**19073** (BNL-50120(Pt.2), pp 755-64) PROGRESS REPORT ON THE INVESTIGATIONS OF SUPERCONDUCTING STRUCTURES AT KARLSRUHE. Schopper, H. (Kernforschungszentrum, Karlsruhe (West Germany). Institut Experimentelle Kernphysik. Technische Hochschule, Karlsruhe (West Germany). Institut fuer Experimentelle Kernphysik).

A brief description of the research on superconducting accelerating structures being done at Karlsruhe is presented. Topics discussed are preparation of superconducting surfaces, measurements and results of Q-values, effects at high-energy electric fields, Optimization of structures for proton acceleration, and superconducting particle separators. (B.G.D.)

**19074** (BNL-50120(Pt.2), pp 765-9) INVESTIGATION OF ADDITIONAL LOSSES OF SUPERCONDUCTING CAVITIES DUE TO FIELD DEPENDENT EFFECTS AT HIGH LEVELS. Kuehn, W. (Technische Hochschule, Karlsruhe (West Germany). Institut fuer Experimentelle Kernphysik. Kernforschungszentrum, Karlsruhe (West Germany). Institut Experimentelle Kernphysik).

The cavity model used, the principle of measurements, and the experimental results of an investigation on additional losses of superconducting cavities due to field dependent effects at high levels are discussed. (B.G.D.)

**19075** (BNL-50120(Pt.2), pp 770-3) Q-MEASUREMENTS IN SUPERCONDUCTING LEAD CAVITIES AT 800 MHz. Flecher, P.; Halbritter, J.; Hietschold, R.; Kneisel, P.; List, L.; Stoltz, O. (Technische Hochschule, Karlsruhe (West Germany). Institut fuer Experimentelle Kernphysik. Kernforschungszentrum, Karlsruhe (West Germany). Institut Experimentelle Kernphysik).

Q measurements were made for two types of superconducting lead cavities. The first was a cylindrical cavity quoted in the $TE_{011}$ made at 800 MHz and the second was a shorted coaxial line quoted in the $TEM_{001}$ mode at 750 MHz. A comparison between the theory and experimental results was also made. (B.G.D.)

**19076** (BNL-50120(Pt.2), pp 775-802) NON-CRYOGENIC HIGH DUTY CYCLE ELECTRON LINEAR ACCELERATORS. Haimson, J. (Massachusetts Inst. of Tech., Cambridge).

The design characteristics of linear accelerators having high duty factor systems which utilize normal disc loaded traveling wave structures designed to operate over a wide dynamic range of peak rf power to provide narrow-energy-spectra, low-emittance beams of high intensity are discussed. Brief descriptions are presented of the rf system and beam centerline components of the MIT accelerator to further illustrate some of the design problems common to high duty factor machines. (B.G.D.)

**19077** (CEA-R-3261) DETERMINATION OF THE 20 MeV LINEAR ACCELERATOR, NEW INJECTOR FOR THE SYNCHROTRON SATURNE, CHOICE OF THE ELECTRICAL AND DYNAMICAL PARTICLE PARAMETERS. Prome, Michel (Commissariat a l'Energie Atomique, Saclay (France). Centre d'Etudes Nucleaires). Dec. 1968. 113p. (In French). Dep.

Thesis. Submitted to Univ., Paris.

Design parameters of the 20 MeV linear accelerator which will be the new Saturne injector are determined. Starting from beam requirements at the output of the linac, cell lengths with variable synchronous phase angle, buncher and debuncher parameters, and beam emittances at the output in several phase spaces are successively determined. (auth)

**19078** (CEA-R-3646) DEVELOPMENT OF A SLOW MONO-KINETIC ELECTRON SOURCE. Ballu, Yves (Commissariat a l'Energie Atomique, Saclay (France). Centre d'Etudes Nucleaires). 1968. 113p. (In French). Dep.

Thesis. Submitted to Paris Univ., Orsay, France.

A comparative study of existing slow mono-kinetic electron guns shows that those using a 127° electrostatic selector can be improved still further to arrive at the performances obtained with spherical 180° selectors. For this reason the 127° selector was examined theoretically in more detail; it appears that it should be possible to obtain a resolving power better than 30 MeV for a current of about $10^{-10}$ A, on condition that certain improvements be made to the instrument as normally designed, in particular concerning the entrance and exit slides. As a result, the usual suppressors for the scattered electrons are no longer necessary. The dimensional characteristics are fixed to an accuracy of a few microns, although the instrument can be baked out at 300°C. The experimental results are in excellent agreement with the theoretical predictions: for a current of $10^{-10}$ A, the measured resolving power is 24 ± 4 MeV. The easy detection of the $He^-$ resonance line at 19.3 eV has confirmed the advantages of this apparatus for the study of atomic collisions. (auth)

**19079** (GEPP-49) ELECTRON FOCUSING BY AN ION BEAM. Terhune, J. H. (General Electric Co., St. Petersburg, Fla. Neutron Devices Dept.). Oct. 22, 1968. Contract AT(29-2)-656. 20p. Dep. CFSTI.

The effect of ionic space-charge on secondary electron current density in a uniform accelerating space is computed using a model that neglects electronic screening and non-uniformities in the accelerating field. For sufficiently large ion current and/or sufficiently small electron temperature, a radial non-uniformity can develop in an initially uniform electron current density. This effect manifests itself in focusing of the secondary electrons on the ion source aperture. The magnitude of the electron focusing is calculated for two physical cases. (auth)

**19080** (IFVE-INZH-68-35-K) SELF-FOCUSING PROTON LINEAR ACCELERATOR. Teplyakov, V. A.; Mal'tsev, A. P.;

Ermakov, S. M.; Zotov, A. V.; Yurchenko, V. A. (Gosudarstvennyi Komitet po Ispol'zovaniyu Atomnoi Energii SSSR, Serpukhov. Institut Fiziki Vysokikh Energii). 1968. 10p. (In Russian). Dep.

The parameters of a self-focusing proton linear accelerator are discussed. The energy of accelerated particles is 50 MeV, and the beam current is 100 mA. The accelerating system is based on an H-cavity, whose diameter is 3 to 5 times smaller than that of an Alvarez cavity of the same wavelength. It is shown that focusing by means of an accelerating field in the structure of double-gap drift tubes can provide the specific acceleration not less than $2.7 \cdot 10^{-3}$ and normalized acceptance of the channel not less than 1 mrad·cm. (auth)

**19081** (IFVE-SKU-68-48-K) SYSTEM FOR THE INJECTION OF PARTICLES INTO THE PROTON SYNCHROTRON IHEP AT ENERGY 70 GeV. Boiko, S. N.; Zaitsev, V. I.; Myae, E. A.; Roife, I. M.; Stekol'nikov, B. A. (Gosudarstvennyi Komitet po Ispol'zovaniyu Atomnoi Energii SSSR, Serpukhov. Institut Fiziki Vysokikh Energii). 1968. 31p. (In Russian). Dep.

The problems connected with the design and adjustment of the injection system of the 70 GeV proton synchrotron are discussed. Some considerations connected with injection of the beam into the accelerator, demands to the system characteristics, and the results of the adjustment and work with the beam are given. (auth)

**19082** (ITEF-617) EXPERIMENTAL INVESTIGATION OF THE DYNAMICS OF PROTONS IN A TIGHTLY-FOCUSED LINEAR ACCELERATOR. Batalin, V. A.; Kapchinskii, I. M.; Plotnikov, V. K. (Gosudarstvennyi Komitet po Ispol'zovaniyu Atomnoi Energii SSSR, Moscow. Institut Teoreticheskoi i Eksperimental'noi Fiziki). 1968. 26p. (In Russian). Dep.

The data on the momentum spread of particles for large and small beam currents in different operation conditions of the linac injector of the ITEP proton synchrotron are given. The method of measurement and evaluation of spectra are described. The experimental data are compared with theoretical estimates. The question on the dependence of the beam energy spectrum on the accelerating conditions is discussed. The transverse phase space of the beam is estimated. (auth)

**19083** (LA-4080(Rev.)) SOME PHYSICS USES OF LAMPF: 1968 SUMMER STUDY GROUP AT LOS ALAMOS. Gram, Peter A. M. (Los Alamos Scientific Lab., N. Mex.). Jan. 16, 1969. Contract W-7405-eng-36. 56p. Dep. CFSTI.

A summary of 30 talks presented at the 1968 Summer Study Group on Physics Uses of LAMPF is presented. These talks include recent developments in elementary particle physics, proposed experimental facilities for LAMPF, and proposals for experiments to be performed at LAMPF. (W.H.K.)

**19084** (NP-17766(Pt.2)) INTRODUCTION TO THE PHYSICS OF THE ELEMENTARY PARTICLES. II. SEVERAL EXPERIMENTAL TECHNIQUES. Gerber, H. J. (Geneva Univ., (Switzerland). Laboratoire de Physique Nucleaire Experimentale). [1966]. 108p. (In French). Dep.

Experimental techniques used in the study of elementary particle physics are outlined. These include techniques used with a proton synchrotron, a secondary particle beam, detectors and targets. Exercises to be solved are given at the end of the chapter. (J.S.R.)

**19085** (ORNL-4386) HIGH-ENERGY MUON TRANSPORT AND THE MUON BACKSTOP FOR A MULTI-GeV PROTON ACCELERATOR. Alsmiller, R. G. Jr.; Barish, J. (Oak Ridge National Lab., Tenn.). Mar. 1969. Contract W-7405-eng-26. 19p. Dep. CFSTI.

High-energy muon transport calculations are presented and the "shape" of the muon backstop required for a 200- and a 500-GeV proton accelerator is determined. The shield material considered is heavy concrete. Results obtained with an energy-dependent and an energy-independent stopping power are presented and compared. The error introduced by using a constant stopping power is clearly evident, but it may be tolerable for some design purposes. (auth)

**19086** (UCRL-71405) ASTRON LINEAR ACCELERATOR. Beal, J. W.; Christofilos, N. C.; Hester, R. E. (California Univ., Livermore. Lawrence Radiation Lab.). Feb. 20, 1969. 6p. (CONF-690308-2). Dep. CFSTI.

From Particle Accelerator Conference, Washington, D. C.

The design and operation of the 4.2-MeV, 800-A induction-type electron linear accelerator for the Astron thermonuclear reactor experiment are discussed. (W.H.K.)

**19087** (UCRL-71415) COLLECTIVE ION ACCELERATION AT VERY HIGH ENERGY IN A STATIC MAGNETIC FIELD. Christofilos, Nicholas C. (California Univ., Livermore. Lawrence Radiation Lab.). Sept. 18, 1968. 4p. (CONF-690308-3). Dep. CFSTI.

From Particle Accelerator Conference, Washington, D. C.

A method for accelerating ions is described in which extremely relativistic electrons are injected in a static magnetic field and form a ring which subsequently is compressed by a sequence of axial accelerations and decelerations. Ions trapped in the electrostatic field of the electron ring can in principle be accelerated in a decreasing magnetic field to very high energy ($\gamma_i$) where ($\gamma_i < \gamma_e$ and $\gamma_i$, $\gamma_e$ are the final ion and electron energy, respectively, expressed in rest mass units. The electrons in the ring are confined by an external magnetic field. Radial stability of the trapped ions is provided by imposing on them an azimuthal momentum equal and opposite to the electron aximuthal momentum so that both ions and electrons are magnetically focused by the external magnetic field. The ions are initially accelerated by adiabatic expansion of the ring in a decreasing magnetic field; subsequently the ring is decelerated at constant radius. During this step the ions acquire an azimuthal mechanical momentum almost equal to that of the relativistic electrons. The azimuthal momentums of the ions and electrons are subsequently equalized by allowing the electrons to lose energy by synchrotron radiation. Preliminary parameters are presented for such a static-magnetic-field ion accelerator capable of producing 1000-GeV ions. (auth)

**19088** DETERMINATION OF ION TRAJECTORIES IN ACCELERATING TUBES. Kostka, Pal; Dobrosz, Marian. KFKI (Kozp. Fiz. Kut. Intez.) Kozlem., 17: 58-72(1969). (In Hungarian).

Numerical calculations were performed in connection with some problems of ionoptics in the accelerating tube of a Van de Graaff generator. Calculating the degree of focusing, primarily the effect of a change in the nominal voltage distribution was investigated. The calculation method is described and some results are discussed. The ICT 1905 computer was used for the calculations. (auth)

**19089** PULSED NEUTRON GENERATOR FOR REACTOR PHYSICS. Szabo, Zoltan; Dekany, Istvan. KFKI (Kozp. Fiz. Kut. Intez.) Kozlem., 17: 3-19(1969). (In Hungarian).

A pulsed D-T neutron generator NEG-200 was developed and built for measurements in multiplying media. The pulse target current is 5 mA, the pulse length is variable from 10 μs to 1 ms, the repetition frequency from 0.1 to 2000 pps, the maximum duty cycle is 2%. The accelerating tube can be set to any position between the horizontal and vertical directions. The height of the rotational axis of the accelerating tube is variable from 0.90 to 2.00 m above floor level. The 200 kV accelerating voltage is supplied by an insulating core transformer. (auth)

**19090** METHOD FOR ESTIMATING THE INTERNAL STRUCTURE OF NONLAMINAR INTENSIVE BUNCHES OF CHARGED PARTICLES WITH AXIAL SYMMETRY. Kuznetsov, V. S.; Fidel'skaya, R. P. Zh. Tekh. Fiz., 38: 1756-61(Oct. 1968). (In Russian).

A method for estimating the internal structure of charged-particle bunches for the case of plane symmetry is generalized for the case of axial symmetry. The method utilizes a system of equations of self-coordinated fields for describing the distribution of particles according to coordinates and velocity. (tr-auth)

**19091** SATURATED CURRENTS OF PROTONS IN ACCELERATION TUBES WITH STRONG FOCUSING. Abramyan, E. A.; Vecheslavov, V. V.; Kononov, V. I. Zh. Tekh. Fiz., 38: 1762-8 (Oct. 1968). (In Russian).

The motion of intense proton bunches in acceleration tubes with strong-focusing by quadrupole lenses is discussed. A relation was determined for the number of protons being accelerated by the tube at maximum current from the phase volume of the particle bunch. This was necessary for determining the saturated regions of acceleration. The characteristics obtained can be used for the selection of the working region of the tube, the proton injector, and the ion-optical systems. (tr-auth)

**19092** RESONANT INJECTION ACCORDING TO TWO DEGREES OF FREEDOM IN STRONG-FOCUSING SYNCHROTRONS. Titov, V. A.; Shukeilo, I. A. Zh. Tekh. Fiz., 38: 1752-5(Oct. 1968). (In Russian).

The process of beam injection in a synchrotron according to radial and vertical resonant oscillations is considered. The particle bunch is introduced in the region of the chamber in the mean plane of the accelerator, so that the amplitude of the radial oscillations is close to half the width of the chamber. The coupling of oscillations leads to a decrease in the amplitude of radial oscillations and an increase in the amplitude of vertical oscillations. With the optimum chosen continuance of injection it is possible to

fill all of the cross-section of the chamber. In certain cases such an injection permits weakening of the influence of electromagnetic interactions of particles in bunches. A theoretical analysis of the movement of the bunch under the conditions of resonance in coupling of betatron oscillations is presented. Complete calculations for the Serpukhov proton synchrotron at 70 GeV are included. (tr-auth)

**19093** CLASS OF EXACT INVARIANTS FOR CLASSICAL AND QUANTUM TIME-DEPENDENT HARMONIC OSCILLATORS. Lewis, H. R. Jr. (Los Alamos Scientific Lab., N. Mex.). J. Math Phys. (N.Y.), 9: 1976-86(Nov. 1968). (LA-DC-9020).

A class of exact invariants for oscillator systems whose Hamiltonians are $H = (1/2\epsilon)\ [p^2 + \Omega^2(t)q^2]$ is given in closed form in terms of a function $\rho(t)$ which satisfies $\epsilon^2 d^2\rho/dt^2 + \Omega^2(t)\rho - \rho^{-3} = 0$. Each particular solution of the equation for $\rho$ determines an invariant. The invariants are derived by applying an asymptotic theory due to Kruskal to the oscillator system in closed form. As a consequence, the results are more general than the asymptotic treatment, and are even applicable with complex $\Omega(t)$ and quantum systems. A generating function is given for a classical canonical transformation to a class of new canonical variables which are so chosen that the new momentum is any particular member of the class of invariants. The new coordinate is, of course, a cyclic variable. The meaning of the invariants is discussed, and the general solution for $\rho(t)$ is given in terms of linearly independent solutions of the equations of motion for the classical oscillator. The general solution for $\rho(t)$ is evaluated for some special cases. Finally, some aspects of the application of the invariants to quantum systems are discussed. (auth)

**19094** DEVICE FOR ACCELERATING PARTICLES. Speciale, Rosario Aldo (to North American Philips Co., Inc.). U. S. Patent 3,427,557. Feb. 11, 1969. Priority date Apr. 22, 1965, Netherlands.

A particle accelerating device of the cyclotron type employing at least three accelerating electrodes having equal aperture angles and comprised of two opposing sections substantially in the form of sectors of a circle is described. The electrodes are connected together in such manner that each electrode is connected, at its periphery, to two other electrodes located symmetrically relative to one of the electrodes. The connections, together with the electrodes constitute a delay line whose length is a whole multiple of a high-frequency wave on it and in which high frequency can circulate either in the same direction as, or in a direction opposite to the particles being accelerated. The delay line is coupled at a number of points not exceeding half the number of electrodes to a high-frequency generator. (auth)

**19095** HIGH FREQUENCY VAN DE GRAAFF ION SOURCE KINEMATICS. Singhal, R. P.; Roper, J. G.; Knowles, H. B.; Bunch, S. M. (Washington State Univ., Pullman. Rev. Sci. Instrum., 40: 493-4(Mar. 1969).

Calculations of the effects of probe voltage, magnetic field strength, and configuration on the operation of an rf ion source for particle accelerators employing a strong magnetic field at the extraction tip are presented. (W.H.K.)

**19096** PULSE WIDTH MODULATED OPTICAL DATA LINK. Witkover, R. L. (Brookhaven National Lab., Upton, N. Y.). Rev. Sci. Instrum., 40: 469-72(Mar. 1969).

A compact data transmission system for crossing a high voltage interface has been built and tested. The system employs an infrared, incoherent light emitting diode and a silicon photodiode detector to telemeter the pulse width modulated signals. Departure from linearity was observed to be 2.7% rms. The frequency response was 3 dB down at 10 kHz. (auth)

**19097** PHASE-SPACE DYNAMICS OF PARTICLES. Lichtenberg, Allan J. Wiley Series in Plasma Physics. New York, John Wiley and Sons, Inc., 1969. 345p. $16.00.

Phase-space concepts for beams, accelerators, and confined particles are reviewed and their relation to basic theory and earlier developments is given. The concepts and fundamental theory, adiabatic invariants, phase-space transformations, particle dynamics in accelerators, and applications to plasmas are discussed. (W.H.K.)

**19098** ABERRATIONS OF ELECTROSTATIC QUADRUPOLE LENSES RELATED TO FIELD SYMMETRY DISTORTION. Ovsyannikova, L. P.; Yavor, S. Ya. (Leningrad State Univ.). Zh. Tekh. Fiz., 38: 1810-13(Oct. 1968). (In Russian).

The influence of field symmetry distortion on the focusing quality of quadrupole lenses is discussed. The distortion is a result of mechanical inaccuracies in fabricating and assembling the lenses. (tr-auth)

**19099** EXPERIMENTS ON FORMING INTENSE RINGS OF ELECTRONS SUITABLE FOR THE ACCELERATION OF IONS. Keefe, D.; Lambertson, G. R.; Laslett, L. J.; Perkins, W. A.; Peterson, J. M.; Sessler, A. M.; Allison, R. W. Jr.; Chupp, W. W.; Luccio, A. U.; Rechen, J. B. (Univ. of California, Berkeley). Phys. Rev. Lett., 22: 558-61(Mar. 17, 1969).

Electrons were injected from a 3.3-MeV 300-A accelerator into a circular orbit in a pulsed magnetic field. Trapped ring currents of 150 A were magnetically compressed from 19- to 3.5-cm radius and simultaneously accelerated from 3.3 to 18 MeV. The rms dimensions of the cross section of the ring after compression were $a = 2.3 \pm 0.2$ mm radially and $b = 1.6$ to 0.2 mm axially. The lifetime of the ring, typically 5.5 msec, was determined by the decay of the magnetic field after compression and could be decreased by the addition of hydrogen gas, indicating the focusing effect of the trapped positive ions. (auth)

**19100** DESIGN AND CONSTRUCTION OF A COLD TRAP AND BACKGROUND SUPPRESSION IN (p,γ) RESONANCE REACTION MEASUREMENTS. Ahmed, N.; Awal, M. A.; Rahman, M. A.; Khatun, S. (Atomic Energy Centre, Decca, Pakistan). Nucl. Sci. Appl., Ser. B, 4: 25-8(Oct. 1968).

A cold trap was designed and constructed using a Speedivac Vapour Trap, and the deuterium contamination of the Van de Graaff accelerator was minimized. This was done with the intention to lower the general background in (p,γ) resonance reaction measurements. The adequacy of these measures were tested with $^{54}Fe(p,\gamma)^{55}Co$ reaction and it was observed that the background has been suppressed satisfactorily by a factor of 7 compared to previous measurements. (auth)

**19101** BEAM ENERGY CALIBRATION OF 3 MeV VAN DE GRAAFF ACCELERATOR AT DACCA. Ahmed, N. (Atomic Energy Centre, Dacca, Pakistan); Rahman, M. A.; Begum, N. J. F. Nucl. Sci. Appl., Ser. B, 4: 8-12(Oct. 1968).

Beam energy calibration of the Van de Graaff accelerator and the K-value of the analyzing magnet have been measured to be 700 eV and 7.036 keV/MC/Sec)$^2$ respectively. $^{27}Al(p,\gamma)^{28}Si$ reactions have been measured from 0.85 to 1.74 MeV. The variation of K up to 1.4 MeV is found very small and it can be concluded that K-value does not show any definite saturation effect below this energy region. (auth)

**19102** BREMSSTRAHLUNG DISTRIBUTION AROUND VAN DE GRAAFF ACCELERATORS. Hussain, M. (Univ. of Dacca, Pakistan); Rab Molla, M. A.; Abdullah, S. A. Nucl. Sci. Appl., Ser. B, 4: 29-35(Oct. 1968).

The production and characteristics of bremsstrahlung from different types of Van de Graaff accelerators, i.e., positive ion, electron and x-ray type machines are reviewed. Radiation dose distribution due to bremsstrahlungs for a 3 MeV positive ion Van de Graaff accelerator (type KN49 HVEC) at Dacca are also discussed. The dose rates around the machine were measured at different machine operating conditions and typical isodose curves are plotted. It is observed that the dose rates in all directions are roughly proportional to the inverse square of the distance and are independent of the vertical height. It is also observed that the dose rates are linear functions of beam current and increase exponentially with the beam energy in the range of 1–2 MeV. The average or effective energy of bremsstrahlung at a point near the machine is determined for the beam energy of 1.5 MeV and found to be 0.51 MeV. (auth)

**19103** 70-GeV PROTON SYNCHROTRON AT SERPUKHOV. STARTUP AND ADJUSTMENT OF THE ACCELERATOR. Naumov, A. A. Vestn. Akad. Nauk SSSR, No. 8, 58-65(Aug. 1968). (In Russian).

A 70-GeV proton synchrotron with strong focusing uses a linear accelerator as an injector which gives up to 100-MeV protons at 100 mamp current per pulse. From the linear accelerator through a special ion channel having a length of 80 m with a strong-focusing optical system, the protons are introduced into the annular vacuum chamber of the synchrotron, which has a transverse cross-section of $195 \times 115$ mm, and is made of crimped stainless steel with a thickness of 0.4 mm. The system is pumped down by 120 pumps, each having a capacity of 300 l/sec. The vacuum chamber is placed between the poles of a circular electromagnet so as to move the protons in a circular orbit with focusing in the vertical and radical directions. The electromagnet is made of 120 blocks, each weighing 200 tons in a circle of 1.5 km. Strong focusing is attained by alternating with positive and negative gradients of the magnetic field. A total of 12 different systems allow both passive and active correction of the characteristics. The accelerating electric field is created by 54 high-frequency resonators placed on a circle between the blocks of the electromagnet. The vacuum chamber has attained its design value of $2 \times 10^{-6}$ torr. In spite of

careful testing, the blocks do not meet the design characteristics in magnetic properties, and were installed in the circle on the basis of magnetic measurements carried out on each individual piece. Optimal conditions for injection and acceleration of protons were found by further testing. The beam intensity is being increased at present to $10^{11} - 10^{12}$ particles per pulse. (TTT)

**19104** LINEAR ACCELERATOR-INJECTOR. Mints, A. L. Vestn. Akad. Nauk SSSR, No. 8, 66-75(Aug. 1968). (In Russian).

The linear accelerator which serves to inject 100-MeV protons into the 70-GeV proton synchrotron at Serpukhov has the following characteristics: 700-keV energy of injection; 100-MeV exit energy; 50 to 100 mamps of beam current; 12 to 40 μsec for duration of proton pulse current; 0.2 to 1 cycles/sec for the frequency of the accelerating field; amplitude of the average field tension on the axis of ~18 kV/cm; three resonators with lengths of 29.9, 27.6, and 21.9 m and Q-factors of 42,000 to 68,000; pulse power of the copper losses of 2.0 to 2.5 megawatts; 300 μsec for the duration of the high-frequency pulses; ±0.3% for the relative momentum dispersion of the particles at the exit; 3.1 to 4.8 cm-mrad for the effective transverse phase volume of the beam at the exit; ±1 to 2% for the inhomogeneity of the electric field along the axis; ±3° for the phase stability of the high-frequency field; 50μ tolerance for displacement of the axis of the quadrupole lenses with respect to the axis of the accelerator; and ±1% for the stability of the magnetic field gradient in each lens. (TTT)

**19105** THE $^{12}C(\gamma,x)^{7}Be$ REACTION AS A MONITOR FOR HIGH ENERGY BREMSSTRAHLUNG BEAMS. di Napoli, V. (Univ., Rome). Nucl. Instrum. Methods, 69: 155-6(Mar. 1969).

The use of the $^{12}C(\gamma,x)^{7}Be$ reaction as an absolute monitor for high energy, high intensity bremsstrahlung beams is discussed. An absolute cross-section of (0.12 ± 0.02) mbarn was found for $^{7}Be$ production in the energy range 0.4 GeV to 0.9 GeV. (auth)

**19106** DETERMINATION OF 1 MeV NEUTRON FLUXES FROM THE $T(p,n)^{3}He$ REACTION BY THE ASSOCIATED PARTICLE METHOD. Liskien, H.; Paulsen, A. (EURATOM, Geel, Belg.). Nucl. Instrum. Methods, 69: 70-6(Mar. 1969).

One MeV neutron fluxes were produced via the $T(p,n)^{3}He$ reaction and determined by counting the associated $^{3}He$-particles under 30° with respect to the proton bombardment direction. Targets of 0.2 mg/cm² T–Ti on 1.1 mg/cm² Al foils were used. An electrostatic field was applied to reduce the background produced by the Coulomb scattered protons and other charged particles. The results of this method were compared with those of two other methods (recoil proton telescope and methane-filled proportional counter) both based on n-p scattering. Agreement within 2% was found for all three methods. (auth)

**19107** A HIGH ENERGY, SMALL PHASE-SPACE VOLUME MUON BEAM. Cox, J.; Martin, F.; Perl, M. L.; Tan, T. H.; Toner, W. T.; Zipf, T. F.; Lakin, W. L. (Stanford Univ., Calif.). Nucl. Instrum. Methods, 69: 77-88(Mar. 1969).

The design and performance of a high-momentum, small phase-space volume muon beam is described. The muons are photoproduced by the bremsstrahlung of electrons incident on a thick target. Pion contamination is reduced to $3 \times 10^{-6}$ of the muon flux by a 5.5 m beryllium filter placed immediately after the target. The optical system has two stages of momentum analysis to give an almost dispersion free beam, and a final imaging stage to clean up the tails of the beam distribution. Standard BNL 8Q48 and 18D72 magnets are used throughout. At 10 GeV/c, the beam yields $1.0 \times 10^{6}$ $\mu^{+}$/sec in a phase-space volume of $3 \times 10^{-3}$ cm²· sterad. and a momentum band of ±1.5%. (auth)

**19108** METHOD FOR EFFICIENT MAGNETIC ANALYSIS IN AN INHOMOGENEOUS FIELD. Lechanoine, C. (Faculte des Sciences, Paris); Martin, M.; Wind, H. Nucl. Instrum. Methods, 69: 122-4(Mar. 1969).

A method is described to determine the momentum of a particle from points of its trajectory through an inhomogeneous magnetic field. A number of representative trajectories are computed and used to express the momentum explicitly in terms of observable quantities. Compared with the method of calculating a trajectory for each event with a stored field map, a gain in computing time and a reduction of storage capacity required were achieved of several orders of magnitude. (auth)

**19109** AT THE CERN PROTON SYNCHROTRON: TOWARDS $10^{13}$ PROTONS PER SECOND. Bayard, Oliver; Reich, Karl Helmut (CERN, Geneva). Ind. At. 12: No. 11–12, 31-9(1968). (In French).

After having shown how the increasing experimental use of accelerated protons in the CERN synchrotron encouraged the Council of CERN to set up an extensive program of improvements, detailed explanations of the two distinct stages of that program are given. (1) The installation and operation of a new feed for the magnet of the proton synchrotron, so that the frequency of the cycles of acceleration can henceforward be stepped up. O. Bayard indicates the importance of the work involved and the progress achieved, by means of a comparison with the former feed system. (2) The construction work begun on a new injector which will make it possible to raise the number of protons accelerated by impulsion from $10^{12}$ to $10^{13}$. K. H. Reich then outlines the physical problems which induced CERN to construct a new injector, and goes on to explain the various possibilities open to the promoters of this project, along with the reasons for choosing a synchrotron injector of 800 MeV (the so-called "Booster") with four superposed rings. He concludes with a brief description of the Booster, of the modes of injection into the 28 GeV synchrotron, and of the effect produced by the increased intensity of the beam on its equipment and fittings. (auth)

**19110** THE CERN INTERSECTING STORAGE RINGS (CONCLUSION). Borer, Jean (CERN, Geneva). Ind. At., 12: No. 11–12, 41-8(1968). (In French).

The description of the design and construction of the CERN intersecting storage rings is completed with a discussion of the beam capacitance, the beam transfer and injection system, vacuum control, control system, and civil engineering. (J.S.R.)

**19111** INJECTOR BEAM BUNCHING AT FREQUENCY OF THE ACCELERATING CAVITIES. Esin, S. K.; Petrosyan, M. L. (Inst. of Physics, Erevan). Izv. Akad. Nauk Arm. SSR, Ser. Fiz., 3: 211-16(1968). (In Russian).

By bunching the injector beam at the frequency of the accelerating cavities, only those electrons are accelerated in the injector which can be captured by the acceleration regime in the ring accelerator. The main parameters of the klystron buncher operating with linear accelerators are studied. A cascade bunching is proposed which provides more effective capture of the particles by the synchrotron. (auth)

# PHYSICS (NUCLEAR)

## Neutron Interactions with Matter

*Refer also to abstracts 18726, 19206, 19244, 19321, and 19553.*

**19112** (AE-346) A COMPARISON BETWEEN EFFECTIVE CROSS SECTION CALCULATIONS USING THE INTERMEDIATE RESONANCE APPROXIMATION AND MORE EXACT METHODS. Haeggblom, H. (Aktiebolaget Atomenergi, Stockholm (Sweden)). Feb. 1969. 71p. Dep.

To investigate some aspects of the intermediate resonance approximation developed by R. Goldstein and E. R. Cohen, comparative calculations were made using this method together with more accurate methods. For homogeneous materials the slowing down equation is solved in the fundamental mode approximation with the computer program SPENG. All cross sections are given point by point. Because the spectrum can be calculated for at most 2000 energy points, the energy regions in which the resonances are accurately described are limited. Isolated resonances in the region 100 to 240 eV are studied for $^{238}U$/Fe and $^{238}U$/Fe/Na mixtures. In the regions 161 to 251 eV and 701 to 1000 eV, mixtures of $^{238}U$ and Na are investigated. $^{239}Pu$/Na and $^{239}Pu/^{238}U$/Na mixtures are studied in the region 161 to 251 eV. For heterogeneous compositions in slab geometry, the integral transport equation is solved using FLIS program in 22 energy groups. Thus, only one resonance can be considered in each calculation. Two resonances are considered, namely those belonging to $^{238}U$ at 190 and 937 eV. The compositions are lattices of $^{238}U$ and Fe plates. The computer program DORIX was used for the calculations using the intermediate resonance approximation. Calculations of reactions rates and effective cross sections were made at 0.300 and 1100°K for homogeneous media and at 300°K for heterogeneous media. The results are compared to those obtained by using the programmes SPENG and FLIS and using the narrow resonance approximation. (Sweden)

**19113** (BNL-13257) SPECIFICATION AND CHARACTERIZATION OF NEUTRON DATA. Goldberg, Murrey D. (Brookhaven National Lab., Upton, N. Y.). Feb. 1969. 21p. (CONF-690204-1). Dep. CFSTI.

From I.A.E.A. Panel on Neutron Data Compilation, Upton, N. Y.

The proposed content of the data storage system CSISRS, which is being developed at Brookhaven, is outlined. The specification and characterization of neutron interactions are discussed at length. (D.C.W.)

**19114** (CONF-680501-6) CALCULATION OF THE TWO PHONON COHERENT NEUTRON SCATTERING CROSS SECTION FOR SINGLE CRYSTAL BERYLLIUM IN THE HARMONIC APPROXIMATION. Johnston, A. S. (Westinghouse Electric Corp., Pittsburgh, Pa. Astronuclear Lab.). [nd]. 24p. Dep. CFSTI.

From Symposium on Inelastic Neutron Scattering, Copenhagen, Denmark.

A calculation of the two phonon coherent neutron scattering cross section for single crystal beryllium in the harmonic approximation was done. The calculation was performed by approximating the sums over eigenmodes by sums in which the terms are evaluated at mesh points in the first Brillouin zone. The Born-von Karman model of deWames, Wolfram, and Lehman for beryllium is used. Results are obtained as a histogram giving the scattering law for fixed neutron wave vector change versus the neutron energy transfer. (auth)

**19115** (EUR-4081) MEASUREMENTS OF PULSE SHAPES OF NEUTRON BURSTS IN THE THERMAL AND SUBTHERMAL RANGE AT SINGLE ENERGIES. Riccobono, G.; Fraysse, G.; Menardi, S. (European Atomic Energy Community, Ispra (Italy). Joint Nuclear Research Center). Aug. 14, 1968. 26p. Dep.

The time behavior of neutron pulses was determined at single energies of 5, 20, 80 MeV, following the injection of fast neutron bursts in some moderator configurations at room temperature and at liquid nitrogen temperature. The experimental apparatus is described, and its performance is evaluated. The results are given and discussed from the point of view that the moderator configurations studied should serve as sources of thermal and cold neutrons when coupled to a pulsed fast reactor. (auth)

**19116** (JAERI-1168) MEASUREMENT OF NEUTRON SLOWING DOWN TIME IN HYDROGENEOUS MODERATORS. Kaneko, Yoshihiko; Akino, Fujiyoshi; Kurokawa, Pyosuke; Kitadate, Kenji; Sakamoto, Shigeyasu (Japan Atomic Energy Research Inst., Tokai. Tokai Research Establishment). July 1968. 12p. Dep.

The neutron slowing-down times in light water, ice, paraffin, and santowax-R were obtained by measuring filter transmission rates as a function of time after injections of neutron bursts. The large flight-time effects were taken into account experimentally. The measured slowing-down times below 0.63 and 0.43 eV agreed well with theoretical values on the 0°K free gas model. However, the measured values below 0.20 eV are longer than the theoretical ones, which indicates the effect of the thermal agitation and chemical binding in the range of this energy. (auth)

**19117** (JINR-P14-4270) METHOD OF "RECIPROCAL" GEOMETRY FOR PHONON INVESTIGATION USING THE JINR IBR. Malishevski, E.; Machekhina, T. A.; Nitts, V. V.; Pak Gvan O (Joint Inst. for Nuclear Research, Dubna (USSR). Lab. of Neutron Physics). 1969. 7p. (In Russian). Dep.

The phonon measurements in the "reciprocal" geometry, performed by the time-of-flight method, are described. The measurements were performed using the pulsed fast reactor of the Joint Institute for Nuclear Research. Some neutronograms, obtained in the experiments with the Cu, Al, and Bi single crystals, are given. (auth)

**19118** (JUL-551-RG) CALCULATION OF THE RESONANCE INTEGRAL FOR MULTIPLE HETEROGENEOUS ARRANGEMENTS. Teuchert, E.; Breitbarth, R. (Kernforschungsanlage, Juelich (West Germany). Institut fuer Reaktorentwicklung). Sept. 1968. 36p. (In German). Dep.

The principles for the calculation of multiple heterogeneous arrangements were explained and applied to a series of arrangements. In the ZUT-DG program resonance integral calculations are possible for arrangements in which bare or graphite-coated absorber spheres are arranged in random dispersal or embedded in graphite material. These coated particles can be contained in latticed fuel rods or in spheres randomly dispersed. The results of the calculations are given. (tr-auth)

**19119** (LA-4058) USER'S GUIDE FOR THE TWOTRAN (x,y) PROGRAM. Lathrop, Kaye D. (Los Alamos Scientific Lab., N. Mex.). Dec. 1, 1968. Contract W-7405-eng-36. 23p. Dep. CFSTI.

New difference schemes are described for the two-dimensional transport program TWOTRAN. A general guide to the usage of the program is given. Detailed input instructions for the program are provided. (auth)

**19120** (NP-17787) GRAPHITE PRISM FOR APPLIED NEUTRON PHYSICAL MEASUREMENTS. Deme, Sandor; Makra, Zsigmond; Veres, Zoltan (Magyar Tudomanyos Akademia Kozponti Fizikai Kutato Intezete, Budapest). [1968]. 11p. (In Hungarian). Dep.

A graphite prism, with the dimensions 180 cm by 180 cm by 240 cm, is described. The prism will be used for applied neutron physical measurements, such as the calibration of detectors and the determination of the yield of neutron sources. By varying the location of the neutron source and/or the detector, the spectrum as well as the flux of neutrons can be varied in a wide range. The flux can be evaluated from the activation of foils, or when a source of known yield is used, by calculation. The prism is applicable for the intercomparison of various neutron sources. The prism will be used primarily for the calibration of neutron survey equipment covering a wide range of energies. (auth)

**19121** (RT/FI-(68)38) SPACE-ENERGY NEUTRON KINETICS IN CYLINDRICAL GEOMETRY. Trombetti, T. (Comitato Nazionale per l'Energia Nucleare, Rome (Italy)). 1968. 31p. Dep.

The problem of neutron kinetics in two-dimensional geometry, i.e., the problem of determining the space-angle-energy description of the time-dependent neutron flux distributions is solved. The general case of anisotropic scattering is considered first, and the solution is given the form of an inverse Laplace transform. Finally, it is shown that, in the case of isotropic scattering, this solution splits into the sum of exponential modes plus a transient term. (auth)

**19122** (RT/FI-(68)40) QUANTAL APPROACH TO THE PROBLEM OF NEUTRON MULTIPLE SCATTERING IN A SLAB. Kalashnikov, N. P.; Longo, G. (Comitato Nazionale per l'Energia Nucleare, Rome (Italy)). 1968. 13p. Dep.

The solution of a neutron multiple scattering problem is obtained by using a quantal approach. The elastic isotropic scattering is considered in the approximation where the scattering

length is much less than both the neutron mean free path and the average distance between nuclei. In the case of a finite-thickness slab, the probability density of the neutron momenta as a function of the traversed depth and of the scattering cosine is written directly in quadratures without using the transport equation. (auth)

**19123** (RT/FI-(68)43) EXACT SOLUTION TO THE THREE-DIMENSIONAL TRANSPORT EQUATION FOR MONOENERGETIC NEUTRONS. Boffi, V. C.; Molinari, V. (Comitato Nazionale per l'Energia Nucleare, Rome (Italy)). 1968. 26p. Dep.

A new method for integrating the Boltzmann integro-differential equation governing the monoenergetic neutron stationary flux distributions in a moderator parallelepiped is presented. The scattering is taken to be isotropic in the laboratory system. The central problem is shown to consist in the inversion of the three-dimensional Fourier transform of the total flux, the transform being the solution of a non-Fredholm integral linear equation in three variables. The angular dependence of the flux is also considered. (auth)

**19124** (RT/FI-(68)44) HALF-SPACE TRANSPORT PROBLEMS WITH ANISOTROPIC SCATTERING. Trombetti, T. (Comitato Nazionale per l'Energia Nucleare, Rome (Italy)). 1968. 23p. Dep.

An exact solution to the linear transport problem in a half space with anisotropic scattering and general conditions on the free surface and at infinity is explicitly given. The albedo or diffuse reflection problem is treated as a particular case. (auth)

**19125** (TID-24489(Suppl.)) CINDA 68 SUPPLEMENT: AN INDEX TO THE LITERATURE ON MICROSCOPIC NEUTRON DATA. (Division of Technical Information Extension (AEC), Oak Ridge, Tenn. Gosudarstvennyi Komitet po Ispol'zovaniyu Atomnoi Energii SSSR, Obninsk. Fiziko-Energeticheskii Institut. ENEA Neutron data Compilation Centre, Gif-Sur-Yvette (France). International Atomic Energy Agency, Vienna (Austria). Nuclear Data Unit). Jan. 15, 1969. 188p. (EANDC-77-U(Suppl.); CCDN-CI-23(Suppl.)). DTIE Free.

Additions and revisions to CINDA 68 (Computer Index of Neutron Data) are tabulated. (J.W.R.)

**19126** (UCRL-50532) SORS MONTE CARLO NEUTRON-TRANSPORT CODE FOR THE CDC-6600. Kimlinger, John; Plechaty, Ernest F. (California Univ., Livermore. Lawrence Radiation Lab.). Oct. 24, 1968. 29p. Dep. CFSTI.

The SORS Monte Carlo neutron-transport code is a two- or three-dimensional program for calculating the transport of neutrons in the energy range from thermal to 14.6 MeV. (auth)

**19127** (WANL-TME-1830) THERMAL RANGE LIBRARY FOR GAMB1T PROGRAM. Moran, L. L.; Collier, G.; Johnston, A. S.; Gibson, G. (Westinghouse Electric Corp., Pittsburgh, Pa. Astronuclear Lab.). July 1968. Subcontract NP-1. 114p. Dep. CFSTI.

The cross section library used by the GAMB1T program in the thermal range is described. Also included are sections which describe the UPDATE program which creates and alters thermal library tapes, the MODCHEK program which is used to check moderators, a discussion of the formation of the moderator kernels, and a series of plots of the scattering cross sections of the moderators. (auth)

**19128** THE CONSTRUCTION AND CALIBRATION OF A STANDARD THERMAL NEUTRON FLUX FACILITY AT THE NATIONAL PHYSICAL LABORATORY. Ryves, T. B.; Paul, E. B. (National Physical Lab., Teddington, Eng.). J. Nucl. Energy, 22: 759-75(Dec. 1968).

The standard thermal flux was produced by sources consisting of Be targets bombarded by a deuteron beam from a Van de Graaff accelerator. The sources were set in a large graphite moderator block. The flux was easily controlled over a range of about $10^4$ to $10^8$ n/cm$^2$/sec in a small central region of about 150 cm$^3$ by reference to a standard boron-loaded ionization chamber, and was reproducible to ±0.1% over a period of 6 months. Over this region the flux density was flat to about ±0.2%. The epithermal flux component was at most 1% of the total, and the measured shape of the epithermal flux spectrum was proportional to $E^{-1.05}$, where E is the neutron energy. The Westcott flux convention was modified in order to calculate the reaction rates of materials when the neutron slowing down spectrum varied as $1/E^{1+s}(|s| \ll 1)$. The effective cross section for a thin detector may be written as $\sigma_0 g(T) f C(\beta,T) h(\beta) I'/\sigma_0$, where $C(\beta,T)$ is a renormalization correction to the epithermal flux fraction f at temperature T, $h(\beta)$ is the correction to the reduced resonance integral I' defined for a 1/E flux, $\sigma_0$ is the 2200 m/sec absorption cross section, and g(T) is the Westcott function. (auth) (UK)

**19129** ENERGY-DEPENDENT SHIELDING FACTORS FOR $^{235}$U FOILS FROM TRANSMISSION EXPERIMENTS. Bramblett, R. L.; Czirr, J. B. (Univ. of California, Livermore). Nucl. Sci. Eng., 35: 350-7(Mar. 1969).

A measurement has been made of the effects of flux depression upon the neutron-induced fission rate in $^{235}$U using self-detection techniques. A thin $^{235}$U fission detector was irradiated with neutrons from the LRL electron linear accelerator. The change in the fission counting rate was measured when absorber foils of $^{235}$U were inserted into the neutron beam. The detector consisted of a parallel-plate fission chamber containing eight $^{235}$U foils of thickness ½ mg/cm$^2$ each. The incident neutron energies were measured by time-of-flight within the energy range from 0.46 eV to 2.1 keV and with a timing resolution of 27 nsec/m. The effect of this relatively poor resolution of the energy-averaged fission rate is eliminated by the self-detection technique. The enriched uranium absorber foils varied in thickness from 0.14 to 19 g/cm$^2$, with a $^{235}$U content of 93%. In addition, $^{235}$U fission and total cross sections were measured with comparable resolution. (auth)

**19130** HISTORICAL DEVELOPMENT OF NEUTRON THERMALIZATION. Williams, M. M. R. (Queen Mary Coll., London). Nucl. Energy, 2-11(Jan.-Feb. 1969).

The meaning of neutron thermalization is explained using as an example the infinite medium pulsed neutron problem. Practical problems in which thermalization effects arise are discussed. It is shown how the subject developed from the early classical experiments of Fermi in 1934 to an important branch of reactor physics with two distinct divisions of interest, the academic and the utilitarian. (UK)

**19131** MEASUREMENTS IN PULSED BeO ASSEMBLIES WITH DECAY CONSTANTS IN THE REGION OF CORNGOLD'S LIMIT. Rainbow, M. T. (Univ. of Tasmania, Hobart, Australia); Ritchie, A. I. M. J. Nucl. Energy, 22: 735-49(Dec. 1968).

Decay curves were measured in BeO assemblies with bucklings in the range $1.93 \times 10^{-2}$ to $5.34 \times 10^{-2}$ cm$^{-2}$ at times from immediately after the initial pulse to at least 4.5 msec after the pulse. The decay curves for assemblies with $B^2 \leq 2.91 \times 10^{-2}$ cm$^{-2}$ can be described by an exponential, from a minimum of 1.5 msec to greater than 3.0 msec after the pulse. For bucklings greater than $B^2 = 3.3 \times 10^{-2}$ cm$^{-2}$ the decay curves can not be described by an exponential in this time region, and the departure from exponential increases with increasing bucklings. The results indicate a transition region at $B^2 \sim 3.0 \times 10^{-2}$ cm$^{-2}$ ($\lambda \sim 3.65 \times 10^3$ sec$^{-1}$), which is consistent with the expression proposed by Kothari [NSA, 20: 4815] for the upper limit on discrete decay constants, and well above Corngold's limit of $\lambda^* = (v\,\Sigma_{inel})_{min} \sim 2.5 \times 10^3$ sec$^{-1}$. The transition point does not have any marked shape dependence. There is some shape dependence in the behavior of decay curves for assemblies with $B^2 \geq 3.3 \times 10^{-2}$ cm$^{-2}$, but little dependence on pulse length, or on counter shape and position. (auth) (UK)

**19132** APPLICATION OF LAGUERRE POLYNOMIALS IN THE ANALYSIS OF NEUTRON-WAVE PROPAGATION. Warner, J. H. Jr.; Erdmann, R. C. (Univ. of California, Los Angeles). Nucl. Sci. Eng., 35: 332-41(Mar. 1969).

An energy-dependent transport theory solution for the infinite medium neutron wave propagation problem is obtained by applying a Laguerre polynomial expansion to represent the flux energy dependence. Integral transform methods are utilized to determine solutions appropriate for a general isotropic scattering kernel and general cross sections. Detailed calculations are performed for a two-term polynomial expansion and an energy-dependent cross-section model. Although the polynomial expansion approximation appears to be quite satisfactory for low modulation frequencies, serious inadequacies exist for higher frequencies where continuum effects are important. A critical frequency is not predicted, and the two-dimensional continuum of eigenvalues is approximated by a series of cuts, the number of which depends on the number of terms in the expansion. (auth)

**19133** EXTREMUM VARIATIONAL PRINCIPLES FOR THE MONOENERGETIC NEUTRON TRANSPORT EQUATION WITH ARBITRARY ADJOINT SOURCE. Buslik, A. J. (Bettis Atomic Power Lab., West Mifflin, Pa.). Nucl. Sci. Eng., 35: 303-18 (Mar. 1969).

A self-adjoint positive-definite variational principle is presented which leads to upper and lower bounds for $\langle S^*, \phi \rangle$, where $\langle S^*, \phi \rangle$ is an integral over position and angular direction of the product of the one-velocity neutron transport flux, $\phi$, and an arbitrary adjoint source, $S^*$. The Euler equation of the functional is a new form of the one-velocity Boltzmann neutron transport equation in which the dependent variable is one-half the sum of $\phi$ and $\phi^*$, where $\phi^*$ is the adjoint flux. When a trial function consisting of an expansion in spherical harmonics is used, one obtains as a lower bound for

$\langle S^*, \phi \rangle$ the quantity $\langle US_1, \phi(P-N'; S_1) \rangle - \langle US_2, \phi(P-N''; S_2) \rangle$, where $S_1(r,\Omega) = [S(r,\Omega) + S^*(r,-\Omega)]/2$, $S_2(r,\Omega) = [S(r,\Omega) - S^*(r,-\Omega)]/2$, $\phi(P-N';S_1)$ is an odd P−N approximation to a problem with the same cross sections as the original problem, but with source $S_1$; $\phi(P-N'';S_2)$ is an even P−N approximation to a problem with source $S_2$, and U is the operator that takes a function $f(r,\Omega)$ into $f(r,-\Omega)$. (auth)

**19134** INTRODUCTION TO THE THEORY OF SLOW NEUTRON SCATTERING. Blume, M. (Brookhaven National Lab., Upton, N. Y.). Met. Soc. Conf., 43: 1-14(1968).

From Symposium on Neutron Scattering, Los Angeles, Calif. See CONF-670210.

The resemblance of slow neutron scattering to x-ray scattering is emphasized, but it is pointed out that neutrons can be used to study the thermal excitations of solids. A brief outline is given of the elements of the theory of elastic and inelastic scattering (both magnetic and nuclear), and the types of experiments that can be performed are indicated. (D.L.C.)

**19135** MAGNETIC AND INELASTIC SCATTERING OF NEUTRONS BY METALS. Metallurgical Society Conferences, Los Angeles, Calif., February 22, 1967. Volume 43. Rowland, T. J.; Beck, Paul A. (eds.). Met. Soc. Conf., 43: 1-229(1968). (CONF-670210).

Seven papers are included on the following topics: theory of slow neutron scattering; spin density distribution in Fe, Co, and Ni; magnetic moment distribution in ferromagnetic alloys; neutron diffraction studies of Cr and Cr alloys; magnetic structure of rare earth alloys; spin-wave inelastic scattering on magnetic metals; and atomic vibrations studied by neutron spectroscopy. Separate abstracts were prepared for four of the papers. (D.L.C.)

*For abstracts of individual papers see: 18726−18728 and 19134.*

**19136** THE NEUTRON DATA COMPILATION PROGRAM AT THE IAEA. Lorenz, A. (International Atomic Energy Agency, Vienna). Proc. Nucl. Phys. Solid State Phys. Symp., 1968, Madras, 277-81(1968).

From Nuclear Physics and Solid State Physics Symposium, Madras, India. See CONF-680212.

The objectives and accomplishments to date of the neutron data compilation program at the International Atomic Energy Agency (IAEA) are described. (J.W.R.)

**19137** DETERMINATION OF THE DIFFUSION PARAMETERS OF GRAPHITE BY USING THE PULSED SOURCE METHOD. Blumentritt, G.; Faehrmann, K. (Zentralinstitut fuer Kernforschung, Rossendorf, Ger.). Kernenergie, 11: 281-5(Nov.-Dec. 1968). (In German).

From the curve $\alpha(B^2)$ measured experimentally the diffusion parameters of graphite were found, by means of the ORTHOFIT program, to be $\alpha_0 = 68 \pm 6\ s^{-1}$, $D_0 = 2.17 \pm 0.05 \times 10^5\ cm^{-2}\ s^{-1}$, $C = 42.6 \pm 12 \times 10^5\ cm^4\ s^{-1}$, $F = 10 \pm 8 \times 10^7\ cm^6\ s^{-1}$, reduced to the graphite density value of 1.6 g $cm^{-3}$. The evaluation techniques are described in detail, and the results are compared with those obtained by other authors. (auth)

**19138** ITERATIVE METHODS FOR MULTIPLE SLAB TRANSPORT MODELS. Mingle, J. O. (Univ. of Southern California, Los Angeles). J. Math. Anal. Appl., 25: 372-7(Feb. 1969).

An iterative scheme based upon the invariant embedding approach to transport theory is proposed for the solution of multiple slab transport problems. (D.C.W.)

**19139** CORRECTIONS FOR MULTIPLE SCATTERING DURING EXPERIMENTS ON NEUTRON SCATTERING IN CYLINDRICAL GEOMETRY. Meulders, J. P. (Centre de Physique Nucleaire, Louvain, Belg.). Ann. Soc. Sci. Brux. Ser. I, 82: 307-14 (Dec. 31, 1968). (In French).

Monte-Carlo calculations of the multiple scattering corrections in the elastic and inelastic scattering of 20-MeV neutrons on $^{12}C$ are treated and are discussed for the case of a cylindrical geometry. The importance of the exact treatment of the direction of the neutrons incident upon the sample and emerging from it is outlined. The angular dispersion introduced in the experiment by the sample is also deduced in a rather direct manner from the program. (auth)

## Nuclear Properties and Reactions, A≤5

*Refer also to abstracts 18946, 19026, 19106, 19160, 19164, 19189, 19250, and 19319.*

**19140** (ITF-68-68) DEPENDENCE OF COUPLING ENERGY OF THREE- AND FOUR-PARTICLE SYSTEMS ON THE PARAMETERS OF PAIR POTENTIAL. Maksimenko, V. N.; Antonchenko, V. Ya. (Akademiya Nauk Ukrainskoi SSR, Kiev. Institut Teoreticheskoi Fiziki). 1968. 23p. (In Russian). (CONF-680453-14). Dep.

From 2nd Conference on Axiomatical Field Theory and Theory of Elementary Particles, Kiev, USSR.

A method of determining the parameters depending on the spin of the pair attractive potential, on the basis of experimental data concerning nucleon scattering is presented. The coupling energy of three- and four-particle systems with pair attractive forces of the type $V_0 ch^{-2}\ r/r_0$ and $V_0 \exp\{-r^2/r_0^2\}$ is studied. The Coulomb corrections to the ground-state energy are calculated, and the dependence of coupling energy of the nuclei $^3H$, $^3He$, $^4He$ on the parameters of the pair potential is studied. (auth)

**19141** (RHEL/R-166, pp 91-100) STUDY OF NUCLEAR REACTIONS USING PIONS. Tanner, N. W. (Oxford Univ. (England). Nuclear Physics Lab.).

The current status of studies of nuclear reaction involving pions is discussed. Some comments are made on what may be learned by going to much higher pion energies than are currently being used. (J.W.R.)

**19142** (UCRL-18088) POLARIZATION IN PROTON–HELIUM SCATTERING AT 70 AND 80 MeV. Stetz, Albert W. (California Univ., Berkeley. Lawrence Radiation Lab.). Dec. 1968. Contract W-7405-eng-48. 82p. Dep. CFSTI.

Thesis.

A helium-filled streamer chamber was used to observe the scattering of protons in gaseous helium. With an image intensifier and special high-voltage equipment, consistently good photographs were obtained over many hours of operation. The system made possible good resolution, in the projection mode, of tracks which differed greatly in ionization density. Since the gas in the streamer chamber was used as the scattering target, vertices involving very low-energy particles were observed. The analyzing power in p + $^4He$ elastic scattering was measured at 70- and 80-MeV incident proton energy. With this data, as well as that at 96 MeV and lower energies, the polarization at forward angles is essentially determined from zero to 96 MeV. The forward polarization peak, which increases with increasing energy above 70 MeV, makes helium an attractive analyzer for polarized nucleons at these energies. Phase-shift analyses of the 63.3-, 70-, 80-, and 96-MeV data were completed, and solutions which vary smoothly with energy and are consistent with results at lower energies were obtained. (auth)

**19143** MEASUREMENTS OF THE POLARIZATION OF PROTONS FROM DEUTERON PHOTODISINTEGRATION FOR PHOTON ENERGIES BETWEEN 282 AND 405 MeV. Kose, R. (Univ., Bonn); Martin, B.; Runkel, R.; Wahlen, H.; Kissler, K. H. Z. Phys., 220: 305-20(1969).

The polarization of protons from deuteron photodisintegration was measured at the proton lab angles 60 and 80° for photon energies between 282 and 405 MeV. Carbon was taken as the analyzer. The asymmetry was observed with optical spark chambers. The effective analyzing power of the experimental arrangement was determined by a Monte-Carlo calculation. For the proton lab angle 60° the polarization increases from −0.16 (Basel convention) at a photon energy of 282 MeV to −0.51 at 405 MeV. (auth)

**19144** TWO-PARTICLE PHOTODISINTEGRATION OF THE ALPHA PARTICLE. Jain, S. C. (Allahabad Univ., India); Srivastava, B. K. Proc. Nucl. Phys. Solid State Phys. Symp., 1968, Madras, 233-6(1968).

From Nuclear Physics and Solid State Physics Symposium, Madras, India. See CONF-680212.

The total cross section for the $(\gamma,p)$ reaction on $^4He$ was calculated using modified Irving wave functions with parameters determined from a variational calculation. (J.W.R.)

**19145** HARTREE–FOCK CHARGE DISTRIBUTION IN LIGHT NUCLEI. Kaushal, R. S. (Indian Inst. of Tech., Kanpur). Proc. Nucl. Phys. Solid State Phys. Symp., 1968, Madras, 210-14 (1968).

From Nuclear Physics and Solid State Physics Symposium, Madras, India. See CONF-680212.

Charge distributions were calculated for $^4He$, $^8Be$, $^{12}C$, and $^{16}O$ using spherical Hartree−Fock wavefunctions. The results were compared with experimental data. (J.W.R.)

**19146** NUCLEAR STRUCTURE STUDIES IN LIGHT NUCLEI. Singru, R. M. (Indian Inst. of Tech., Kanpur). Proc. Nucl. Phys. Solid State Phys. Symp., 1968, Madras, 200-3(1968).

From Nuclear Physics and Solid State Physics Symposium, Madras, India. See CONF-680212.

Binding and single-particle energies were calculated for $^{4}$He, $^{8}$Be, $^{12}$C, and $^{16}$O using the Hartree–Fock method with an effective interaction derived from the Yale potential. (J.W.R.)

**19147** SINGLE CHARGE EXCHANGE OF $\pi^{+}$ MESONS AND SPECTROSCOPY OF LIGHT NUCLEI. Kopaleishvili, T. I.. (Tbilisi State Univ., USSR). JETP Lett. (USSR)(Engl. Transl.), 8: 351-4(Nov. 20, 1968).

Translated from Zh. Eksp. Teoret. Fiz., Pis'ma Redaktsiyu, 8: 575-9(Nov. 20, 1968).

The possibility of using the single charge exchange of mesons ($\pi^{\pm}$) in nuclear spectroscopy is discussed using the reaction $^{4}$He($\pi^{\pm}$,$\pi^{0}$) as an example. The calculation of the differential cross section of the reaction $^{4}$He($\pi^{+}$,$\pi^{0}$)$^{4}$Li for excitation of individual levels in $^{4}$Li is considered in detail, as is the extraction of information on the 2$^{-}$ and 0$^{-}$ levels of A = 4 nuclei from the reaction $^{4}$He($\pi^{+}$,$\pi^{0}$)$^{4}$Li. (D.C.W.)

**19148** ALPHA–DEUTERON RESONATING GROUP STRUCTURE OF $^{6}$Li. Ali, S.; Chowdhury, S. M. M. R.; Afzal, S. A. (Atomic Energy Centre, Dacca, Pakistan). Nucl. Sci. Appl., Ser. B, 4: 1-2(Oct. 1968).

The formulation of $\alpha$-d resonating group structure of $^{6}$Li is presented briefly, and quantities of interest in this model are discussed. (auth)

**19149** TRITON AND ALPHA PARTICLE CALCULATIONS WITH A POTENTIAL MATRIX DEDUCED FROM PHASE SHIFTS. Jackson, A. D.; Elliott, J. P. (Univ. of Sussex, Brighton, Eng.). Nucl. Phys., A125: 276-88(1969).

A number of properties of the triton and alpha particle are calculated using matrix elements of the nucleon-nucleon potential in a relative oscillator basis deduced directly from the experimental nucleon-nucleon phase shifts. (auth)

**19150** ELASTIC SCATTERING OF DEUTERONS BY DEUTERIUM. Wilson, A. S.; Taylor, M. C.; Legg, J. C.; Phillips, G. C. (Rice Univ., Houston, Tex.). Nucl. Phys., A126: 193-200 (1969).

Deuteron-deuteron elastic scattering was investigated with a gas target. Excitation curves were taken at 60 and 90° c.m. for lab deuteron energies from 3.5 to 12.25 MeV. Angular distributions were taken at 4.46, 5.46, 6.47, 8.51, 9.53, 10.55 and 11.57 MeV from 40 to 97.5° c.m. Differential cross sections were measured with an absolute error of less than ±3%. (auth)

**19151** PROTON POLARIZATION IN p–$^{3}$He ELASTIC SCATTERING BETWEEN 4 AND 11 MeV. Morrow, L. W.; Haeberli, W. (Univ. of Wisconsin, Madison). Nucl. Phys., A126: 225-32 (1969).

The polarized proton beam from the Wisconsin tandem accelerator was used to measure the proton polarization in p–$^{3}$He elastic scattering at five energies between 4 and 11 MeV in the angular range $\theta_{c.m.}$ = 24 to 156°. A phase-shift analysis of all available data between 1 and 11 MeV was performed. A broad solution region was found which includes solutions found earlier by Tombrello and Drigo et al. (auth)

**19152** MEASUREMENT OF SPIN-CORRELATION EFFECTS IN p–$^{3}$He ELASTIC SCATTERING AT 8.8 MeV. McSherry, D. H. (Rice Univ., Houston, Tex.); Baker, S. D.; Plattner, G. R.; Clegg, T. B. Nucl. Phys., A126: 233-40(1969).

The spin-correlation parameter $A_{yy}$ in p–$^{3}$He elastic scattering was measured at two angles at 8.8-MeV proton lab energy using a polarized proton beam incident on a polarized $^{3}$He target. It is shown that the results significantly reduce the uncertainty with which p–$^{3}$He phase shifts can be determined. (auth)

**19153** STUDY OF THE D(d,d)D, D(d,p)T, AND D(d,n)$^{3}$He REACTIONS WITH POLARIZED DEUTERONS. Bernstein, E. M. (Western Michigan Univ., Kalamazoo); Ohlsen, Gerald G.; Starkovich, V. S.; Simon, W. G. Nucl. Phys., A126: 641-5(1969).

The vector analyzing power of the D(d,d)D, D(d,p)T, and D(d,n)$^{3}$He reactions were measured at 10-MeV deuteron bombarding energy. The analyzing power for elastic scattering is consistent with zero at all angles. The D(d,p)T and D(d,n)$^{3}$He analyzing power is consistent, within the errors, with charge symmetry. (auth)

**19154** ENERGY OF A SIMPLE TRITON MODEL. Kalos, M. H. (New York Univ., N. Y.). Contract AT(30-1)-1480. Nucl. Phys., A126: 609-14(1969).

The energy of a simple three-body nuclear problem that has been extensively studied is calculated again. An exact Monte Carlo method is used together with a procedure for reduction of statistical error based upon a variational expression involving a new trial function particularly appropriate for the problem. The resulting acceleration of convergence greatly reduces computing time for a given accuracy. The final binding energy is in excellent agreement with other work. (auth)

**19155** MEASUREMENT OF (p,p) AND (p,$\alpha$) CROSS SECTIONS FOR LITHIUM AND FLUORINE. Lerner, G. M.; Marion, J. B. (Univ. of Maryland, College Park). Nucl. Instrum. Methods, 69: 115-21(Mar. 1969).

Simultaneous measurements have been made of the differential cross sections ($E_p$ = 1.36 MeV, $\theta_L$ = 90°) for the $^{6}$Li(p,p)$^{6}$Li, $^{7}$Li(p,p)$^{7}$Li, $^{19}$F(p,p)$^{19}$F, $^{6}$Li(p,$\alpha$)$^{3}$He, $^{7}$Li(p,$\alpha$)$^{4}$He, and $^{19}$F(p,$\alpha_0$)$^{16}$O reactions using LiF targets. The measurements provide a consistent set of cross sections for calibration purposes. The results are generally in agreement with previous cross section determinations except for the case of the $^{19}$F(p,$\alpha_0$)$^{16}$O reaction which is discussed in detail. (auth)

## Nuclear Properties and Reactions, 6 ≤ A ≤ 19

*Refer also to abstracts 18821, 19026, 19105, 19139, 19141, 19145, 19146, 19155, 19223, 19246, 19250, 19253, 19254, 19315, 19319, 19358, 19367, 19368, 19373, and 19376.*

**19156** (AWRE-O-60/68) THE CROSS SECTION FOR THE $^{16}$O(n,$\alpha$)$^{13}$C REACTION FOR NEUTRON ENERGIES IN THE RANGE 7–12 MeV. Dandy, D.; Wankling, J. L.; Parnell, C. J. (Atomic Weapons Research Establishment, Aldermaston (England)). Oct. 1968. 14p. Dep. CFSTI. UK 2s. 6d.

The cross sections for the reactions $^{16}$O(n,$\alpha$)$^{13}$C and $^{16}$O(n,$\alpha_0$)$^{13}$C were measured in the neutron energy range from 8 to 12 MeV using monoenergetic neutrons from the tandem Van de Graaff at AWRE Aldermaston. Absolute determinations of these cross sections were not made, but the results were normalized to existing data in the neutron energy range 7 to 8.7 MeV. (auth)

**19157** (JINR-P1-4227) QUASIELASTIC SCATTERING OF 665 MeV PROTONS ON ALPHA-PARTICLE CLUSTERS IN LIGHT NUCLEI. Komarov, V. I.; Kosarev, G. E.; Savchenko, O. V. (Joint Inst. for Nuclear Research, Dubna (USSR). Lab. of Nuclear Problems). 1968. 16p. (In Russian). Dep.

The cross sections for knocking out $^{4}$He nuclei with energy about 470 MeV from $^{6}$Li, $^{9}$Be, $^{12}$C targets at 5.4° to a 665-MeV proton beam were measured. $^{4}$He nuclei were identified by the effective momentum, time-of-flight, specific energy loss, total energy loss, and range. The peak in the momentum spectrum of $^{4}$He nuclei was observed which is caused by the quasielastic scattering of protons by the intranuclear alpha-cluster with 9.5 fermi$^{-1}$ momentum transfer to the alpha particle. The comparison of cross sections obtained for quasielastic scattering with the cross section of elastic proton scattering measured in the same conditions gives the effective numbers of alpha clusters in the investigated nuclei: $N_\alpha(^{6}\text{Li}) = 0.8 \pm 0.2$; $N_\alpha(^{9}\text{Be}) = 1.1 \pm 0.3$; $N_\alpha(^{12}\text{C}) \leq 1.9 \pm 0.4$. These values are close to those obtained using the shell model for alpha-clustering calculations. The results obtained confirm the correctness of basic ideas on quasielastic knocking out of high-energy $^{4}$He by fast protons from light nuclei and, in particular, show the proximity of internal structure of the alpha-cluster and free $^{4}$He nuclei at small (about 0.1 fermi$^{-1}$) relative distances. (auth)

**19158** (NYO-2771-29) NUCLEAR CHEMISTRY RESEARCH: RECOIL STUDIES OF NUCLEAR REACTIONS. Annual Report, January 1968–January 1969. Wolke, Robert L. (Pittsburgh Univ., Pa. Wherrett Lab. of Nuclear Chemistry). Contract AT(30-1)-2771. 39p. Dep. CFSTI.

The pre-equilibrium charge states of recoils from the reactions $^{12}$C(d,d)$^{12}$C and $^{12}$C(d,$\alpha$)$^{10}$B were investigated, and the angular distributions of recoils from the reactions $^{12}$C(d,n)$^{13}$N and $^{6}$Li(d,n)$^{7}$Be at deuteron energies of 12, 15, and 17 MeV were measured. The search for beta instability of $^{113}$Cd was revived following the acquisition of a Sharp Low Beta II counter. (D.C.W.)

**19159** (ORO-2972-88) TWO-NUCLEON TRANSFER IN (d,$\alpha$) REACTIONS. Technical Report No. 6. Curry, J. R.; Riley, P. J.; Coker, W. R. (Texas Univ., Austin. Center for Nuclear Studies). Nov. 1968. Contract AT(40-1)-2972. 171p. Dep. CFSTI.

Angular distributions for the (d,$\alpha$) reactions on $^{12}$C, $^{14}$N, and $^{31}$P were measured in the 10 to 12 MeV incident deuteron energy range. Differential cross sections for the $^{31}$P(d,$\alpha$)$^{29}$Si and $^{12}$C(d,$\alpha$)$^{10}$B reactions were also measured between 13° and 60° at an incident deuteron energy of 33.7 MeV. The experimental angular distributions were fitted and analyzed using a zero-range DWBA two-particle pick-up calculation. In addition, the ground-state reactions were analyzed with a cluster-transfer

approximation. These analyses allowed determination of the dominant L,J values contributing to the various (d,α) reactions studied. Further, nuclear structure factors were computed from shell-model wave functions and tested against the experimental results. (auth)

**19160** (RHEL/R-166, pp 81-90) SCATTERING OF PIONS BY COMPLEX NUCLEI. Stroot, J. P. (European Organization for Nuclear Research, Geneva (Switzerland)).

The use of π-meson scattering in nuclear structure studies is discussed on the basis of single scattering, single and double charge-exchange scattering, and higher-energy scattering experiments. Data on π-mesic x rays and pion scattering by $^{12}C$ and $^{4}He$ are reported. (J.W.R.)

**19161** (UJV-2092-F) THE DIPOLE PHOTODISINTEGRATION OF $^{9}Be$. Majling, L.; Kukulin, V. I.; Smirnov, Y. F. (Ceskoslovenska Akademie Ved, Prague. Ustav Jaderneho Vyzkumu). Oct. 1968. 26p. Dep.

The absorption spectrum for dipole γ quanta with energies below 35 MeV is calculated using the many-particle nuclear shell model. The cross sections of the partial photo-nuclear reactions (γ,n), (γ,p), (γ,d), and (γ,α) and the photonucleon spectra are calculated. Spin-orbit interactions are neglected, and it is assumed that the residual pairing interaction is well described by Serber forces. The supermultiplet structure of the spectrum of excited levels is thus preserved; and the matrix of the Hamiltonian decomposes into a number of submatrices having considerably lower order, each of which can be diagonalized separately. This circumstance makes it possible to consider states that are not directly excited in the γ-quantum absorption, which however do considerably influence the structure of the absorption curve and especially the decay properties of the excited levels and the spectrum of emitted particles. The agreement with the experimental data is very satisfactory. (auth)

**19162** THE ENERGY AND THE ANGULAR DISTRIBUTIONS OF THE $^{16}O(\gamma,p)^{15}N$ REACTION. Shintomi, Takakazu; Masuda, Masayoshi (Tokyo Inst. of Tech.). J. Phys. Soc. Jap., 26: 607-14(Mar. 1969).

The dipole states of $^{16}O$ nucleus are well explained with the theory of the shell model which includes the interaction between one-particle and one-hole. For the evaluation of the single-particle excitation model it is important to investigate the decays of the dipole states of $^{16}O$ to excited states of a residual $^{15}N$ nucleus. The $^{16}O(\gamma,p)^{15}N$ reaction was investigated with nuclear emulsions. An $O_2$ natural gas target was irradiated with bremsstrahlung of 23- and 27-MeV maximum energies from a 31 MeV betatron. The energy distributions were obtained. Almost none of the 22.2-MeV state decayed to the positive-parity doublet of $^{15}N$ at 5.3 MeV and more than 90% of the 24.6-MeV state decayed to the ground state and the third excited state. The results of the present work agreed well with some other experiments. (auth)

**19163** (n,α) REACTION ON $^{12}C$ INDUCED BY 14.1-MeV NEUTRONS. Kitazawa, Hideo; Yamamuro, Nobuhiro (Tokyo Inst. of Tech.). J. Phys. Soc. Jap., 26: 600-6(Mar. 1969).

The (n,α) reaction on $^{12}C$ was investigated by bombarding a thin polyethylene film with 14.1-MeV neutrons. The emitted α particles were detected by a CsI(Tl) scintillation detector and distinguished from other particles by applying the pulse-shape discrimination method. The angular distribution of the α-particles leaving the residual nucleus $^{9}Be$ in the ground state was strongly peaked at about 40° and at the backward hemisphere in the center-of-mass angles, predicting the presence of direct interaction processes. The ground-state transition cross section of 76 ± 11 mb was obtained. The forward peaking was compared with the plane wave theory, for both the pickup and knock-on processes. The reduced width amplitude of the α-cluster at the nuclear surface of $^{12}C$ was determined by attempting the theoretical fit to the backward peak of the angular distribution in terms of the heavy-particle stripping model. Comparing this value with those obtained from other reactions on light nuclei, it seems that the α-cluster reduced width amplitudes are considerably large for the nuclei being amenable to the α-particle model such as $^{12}C$ and $^{16}O$. (auth)

**19164** MULTIPLE COLLISION THEORY AND OPTICAL MODEL OF HIGH-ENERGY SCATTERING FROM NUCLEI. Lesniak, L.; Wolek, H. (Inst. of Nuclear Physics, Krakow). Nucl. Phys., A125: 665-72(1969).

High-energy elastic proton scattering from light nuclei was analyzed. The optical model results for $^{12}C$ and $^{16}O$ were very close to the multiple collision theory predictions; for $^{4}He$, however, the multiple collision theory should be used rather than the optical model. Corrections due to the Pauli principle correlations were found to be small. Theoretical results were compared with the recent experimental data. (auth)

**19165** ANALYSIS OF $^{12}C + ^{3}He$ REACTIONS IN TERMS OF OPTICAL AND STATISTICAL MODELS. Lamba, C. M.; Sarma, N.; Thampi, N. S. (Bhabha Atomic Research Centre, Trombay, India). Proc. Nucl. Phys. Solid State Phys. Symp., 1968, Madras, 371-3(1968).

From Nuclear Physics and Solid State Physics Symposium, Madras, India. See CONF-680212.

The optical and statistical nuclear models were used to analyze $^{3}He$ scattering and reactions with $^{12}C$ at 5.5 MeV. The objective was to study the average properties of the $^{12}C$ nucleus and the structure of $^{15}N$ at high excitation energies. Cross-section calculations were performed using potential parameters fitted from experimental data. (J.W.R.)

**19166** STUDY OF THE REACTIONS $^{19}F(p,\alpha_0)^{16}O$ AND $^{19}F(p,\alpha_{1+2})^{16}O$. Iyengar, K. V. K. (Tata Inst. of Fundamental Research, Bombay); Lal, B.; Mehta, M. K.; Sekharan, K. K.; Vaze, M. Y. Proc. Nucl. Phys. Solid State Phys. Symp., 1968, Madras, 374-8(1968).

The yields of α groups in the reaction $^{19}F(p,\alpha)^{16}O$ were measured to locate resonances in the compound nucleus $^{20}Ne$ and to search for structures wider than the usual compound nucleus resonances. The excitation functions for the α group leading to the ground state of $^{16}O$ were measured at the lab angles of 90 and 120°, and the unresolved groups going to the first and second excited states were measured at 90, 120, and 165°. The proton energy range was 2.000 to 3.625 MeV and measurements were in 25-keV steps. (J.W.R.)

**19167** $^{6}Li(p,pd)^{4}He$ REACTION USING ANTISYMMETRIZED CLUSTER MODEL WAVE FUNCTIONS. Jain, A. K.; Sarma, N. (Bhabha Atomic Research Centre, Trombay, India). Proc. Nucl. Phys. Solid State Phys. Symp., 1968, Madras, 379-81(1968).

From Nuclear Physics and Solid State Physics Symposium, Madras, India. See CONF-680212.

The wavefunction for $^{6}Li$ in the cluster-model analysis of the reaction $^{6}Li(p,pd)$ was antisymmetrized. Plane waves were used for the incoming and outgoing proton and a gaussian wavefunction was used for the free deuteron. The results illustrate the necessity of antisymmetrization in the cluster model. (J.W.R.)

**19168** A STUDY OF THE REACTION $^{12}C(d,p)^{13}C$. Jhingan, M. L. (Tata Inst. of Fundamental Research, Bombay); Bharathi, S. M.; Raheja, U. T.; Ambekar, V. S. Proc. Nucl. Phys. Solid State Phys. Symp., 1968, Madras, 382-5(1968).

From Nuclear Physics and Solid State Physics Symposium, Madras, India. See CONF-680212.

Angular distributions were measured for the $^{12}C(d,p)$ reactions at $E_d$ = 380 to 830 keV in order to determine whether or not the Coulomb interaction between the incident deuteron and the target nucleus has any significant effect on the angular distributions. (J.W.R.)

**19169** INTERMEDIATE STRUCTURE IN $^{19}F(d,\alpha)^{17}O$ REACTION. Betigeri, M. G. (Bhabha Atomic Research Centre, Bombay); Lamba, C. M.; Sarma, N.; Sood, D. K. Proc. Nucl. Phys. Solid State Phys. Symp., 1968, Madras, 386-90(1968).

From Nuclear Physics and Solid State Physics Symposium, Madras, India. See CONF-680212.

Excitation functions were measured for the $^{19}F(d,\alpha)$ reaction at 2 to 5.2 MeV in order to check for resonances due to intermediate structure. Calculations were performed for the $^{21}Ne$ system with a configuration of 5 nucleons outside an inert $^{16}O$ core. The calculated levels were compared with the observed resonances in the $^{19}F(d,\alpha)$ reaction as well as with $^{19}F(d,n)$ and $^{19}F(d,p)$ reactions from other measurements. The agreement with the resonances was very good, supporting the model of Izumo for intermediate states. (J.W.R.)

**19170** A DWBA FIT CALCULATION FOR THE EXPERIMENTAL ANGULAR DISTRIBUTION IN THE $^{12}C(n,\alpha)^{9}Be$ REACTION AT 14 MeV. Chatterjee, M. L.; De, T. (Saha Inst. of Nuclear Physics, Calcutta). Proc. Nucl. Phys. Solid State Phys. Symp., 1968, Madras, 391-5(1968).

The DWBA method was used to fit the experimental angular distribution of the $^{12}C(n,\alpha)$ reaction at 14 MeV. The optical parameters for the neutron and alpha particle were varied to obtain the best fit, and the calculations were simplified by using the zero-range approximation. (J.W.R.)

**19171** STRUCTURE OF MASS-19 NUCLEI. Narayana, K. L. (Shivaji Univ., Kolhapur, India). Proc. Nucl. Phys. Solid State Phys. Symp., 1968, Madras, 260-3(1968).

From Nuclear Physics and Solid State Physics Symposium, Madras, India. See CONF-680212.

The energy-level structure of A = 19 nuclei was investigated using the modified spin-orbit and weak coupling unified model. The results were compared with experimental data. (J.W.R.)

**19172** STRUCTURE OF THE $^{14}N$ NUCLEUS USING DEFORMED ORBITALS. Radhakant, S.; Ullah, Nazakat (Tata Inst. of Fundamental Research, Bombay). Proc. Nucl. Phys. Solid State Phys. Symp., 1968, Madras, 250-4(1968).

From Nuclear Physics and Solid State Physics Symposium, Madras, India. See CONF-680212.

A Hartree–Fock calculation was performed for $^{14}N$ using deformed orbitals. Energy levels, electric and magnetic moments, and transition strengths were determined. (J.W.R.)

**19173** SHAPE ANALYSIS FOR THE 3.5-MeV RESONANCE OBSERVED IN THE ALPHA SCATTERING $^{6}Li$. Balakrishnan, M.; Gupta, S. K.; Mehta, M. K.; Nambiar, K. B. (Bhabha Atomic Research Centre, Trombay, India). Proc. Nucl. Phys. Solid State Phys. Symp., 1968, Madras, 218-20(1968).

From Nuclear Physics and Solid State Physics Symposium, Madras, India. See CONF-680212.

The excitation functions were measured for $\alpha$ elastic scattering by $^{6}Li$ at 3.2 to 3.8 MeV. A shape analysis was performed for the 3.5-MeV resonance corresponding to the 6.56-MeV level in $^{10}B$. The analysis indicates a spin–parity assignment of $2^-$. (J.W.R.)

**19174** SHELL MODEL CALCULATIONS WITH YALE POTENTIAL. Waghmare, Y. R. (Indian Inst. of Tech., Kanpur). Proc. Nucl. Phys. Solid State Phys. Symp., 1968, Madras, 194-6 (1968).

From Nuclear Physics and Solid State Physics Symposium, Madras, India. See CONF-680212.

Shell-model calculations using the Yale potential were performed for the energy levels of $^{10}Be$, $^{58}Ni$, $^{16}O$, and $^{92}Zr$. Core polarizations were not included, but the effect of pairing in $^{16}O$ was considered. (J.W.R.)

**19175** BINDING ENERGIES OF OPEN-SHELL NUCLEI. Dworzecka, Maria (Tata Inst. of Fundamental Research, Bombay). Proc. Nucl. Phys. Solid State Phys. Symp., 1968, Madras, 197-9(1968).

From Nuclear Physics and Solid State Physics Symposium, Madras, India. See CONF-680212.

Binding energies of 2s-1d shell nuclei were calculated using the projected Hartree–Fock method. The calculated energies were 4 to 8 MeV less than experimental values with best agreement for N = Z nuclei. (J.W.R.)

**19176** ON THE RELATIVE SIZE AND BOUNDARY DIFFUSENESS OF THE NUCLEI $^{16}O$, $^{17}O$, AND $^{18}O$. Goldring, G.; Loebenstein, H. M.; Plesser, I.; Sachs, M. W. (Weizmann Inst. of Science, Rehovoth, Israel). pp 291-9 of Spectroscopic and Group Theoretical Methods in Physics. Block, F. (ed.). New York, John Wiley and Sons, Inc., 1968.

Angular distributions were measured for the elastic scattering of $^{16}O$, $^{17}O$, and $^{18}O$ by $^{12}C$ at 35 MeV. The data were analyzed by phase shift methods. The information obtained relates to the relative extension and diffuseness of the nuclear boundary of the oxygen isotopes. (J.W.R.)

**19177** EFFECTS OF INTERFERENCES IN THE REACTION $^{7}Li(d,n)^{8}Be$ IN THE NEIGHBORHOOD OF THE RESONANCE AT 1 MeV. Nussbaum, Christian (Univ. of Neuchatel, Switzerland). Helv. Phys. Acta, 42: 361-84(Apr. 1, 1969). (In French).

Differential cross sections for the reaction $^{7}Li(d,n)^{8}Be$ were measured near and across the resonance at 1 MeV in order to study their behavior and to demonstrate the effects of interference between the resonance and the contributions from weak energy-dependent scattering. Six angular distributions were measured at deuteron energies of 0.91, 0.94, 0.97, 1.01, 1.05, and 1.09 MeV; and two energy distributions were obtained for deuterons of 0.86 to 1.33 MeV at 0 and 90°. A simplified model using two matrix elements gives a satisfactory account the data. (D.C.W.)

**19178** MEASUREMENT OF THE $^{10}B(n,\alpha)^{7}Li$, $^{7}Li^*$ RELATIVE CROSS SECTIONS IN THE keV REGION. Bogart, Donald (Lewis Research Center, Cleveland); Nichols, Lowell L. Nucl. Phys., A125: 463-76(1969).

Relative cross sections for $^{10}B(n,\alpha)^{7}Li$, $^{7}Li^*$ were obtained from measurements of the counting ratios of a $^{10}BF_3$ proportional counter and a precision long counter used to monitor relative neutron fluxes. Monoenergetic neutrons were produced by a Van de Graaff accelerator in the energy region from 30 to 800 keV. When the relative cross sections are normalized to a 1/v variation below 80 keV, the data lie above a 1/v line from 80 to 550 keV indicating departures of 15% at 140 keV and 20% at 220 keV. Measurements were also made of the relative efficiency of a modified long counter used by Bichsel and Bonner to monitor neutron flux in their measurements of the $^{10}B(n,\alpha)^{7}Li$, $^{7}Li^*$ cross sections. The Bichsel and Bonner cross sections also lie above a 1/v line from 80 to 200 keV when corrected from the efficiency of their flux monitor. Recommended cross sections for $^{10}B(n,\alpha)^{7}Li$, $^{7}Li^*$ up to 1 MeV are obtained from recently available measurements and the known levels in $^{11}B$. (auth)

**19179** STUDY OF THE GAMMA RAYS IN $^{18}Ne$. Robertson, B. C.; Bell, R. A. I.; L'ecuyer, J.; Gill, R. D.; Rose, H. J. (Oxford Univ.). Nucl. Phys., A126: 431-48(1969).

Measurements of level positions, lifetimes, spins, and decay modes in $^{18}Ne$ are described. The $^{16}O(^{3}He,n)^{18}Ne$ reaction was used. The 1887.3-keV level ($J^\pi = 2^+$) has $\tau = 0.49$ psec; the 3376.2-keV level has $\tau = 1.9$ psec; the 3576.3-keV level has $\tau > 2$ psec; the 3616.4-keV level has J = 2 and $\tau = 0.063$ psec. Mixing ratios are also reported. Mirror arguments together with the measured lifetimes and angular distributions lead to assignments of J = 4 and J = 0 for the 3376- and 3576-keV levels, respectively. The measured lifetimes were compared, together with those of $^{18}O$, with theoretical predictions. (auth)

**19180** STUDY OF DEFORMATION IN LIGHT NUCLEI. II. APPLICATION TO THE EVEN-PARITY STATES OF THE MASS-18 NUCLEI. Benson, H. G.; Flowers, B. H. (Univ. of Manchester, Eng.). Nucl. Phys., A126: 332-54(1969).

The properties of the low-lying even-parity levels of $^{18}F$ and $^{18}O$ are shown to be well understood in terms of an extended shell-model calculation in which deformed (4-particle-2-hole) states are mixed with the usual two-particle states. The properties of the levels investigated were their energies, electromagnetic decays and reduced widths. The deformed states were constructed by first forming a representation for the ground state band of $^{20}Ne$ and then coupling on to this a complete set of two-hole states formed from $(1p)^{-2}$ oscillator configurations. It is shown that admixtures derived from configurations which include $p_{\frac{1}{2}}$ holes are of much greater importance in the low-lying T = 0 states than in the T = 1 states. It was found that the observed E2 decay strengths in both $^{18}O$ and $^{18}Ne$ require the adoption of an effective charge of about 0.3 e for their explanation. The observed E2 decays in $^{18}F$ between the lower T = 0 levels, however, were well reproduced without effective charge. This feature, for which there is no explanation in terms of the normal effective charge concept, is discussed in terms of second order perturbation theory, which takes into account states in which one particle from the core is promoted through two major shells. (auth)

**19181** CHARGED PARTICLE REACTIONS FROM $^{7}Li + p$ AT 30 MeV. Devins, D. W. (Univ. of Southern California, Los Angeles, Indiana Univ., Bloomington); Bunch, S. M.; Forster, H. H.; Hokhikian, J.; Kim, C. C. Contract AT(04-3)-136. Nucl. Phys., A126: 261-72(1969).

Charged-particle reactions resulting from the bombardment of thin isotopic $^{7}Li$ targets were studied at an incident proton energy of 30.3 MeV. Differential cross sections were obtained for the (p,d) reaction to the ground state and first two excited states of $^{6}Li$ and for the (p,t), (p,$^{3}He$), and (p,$\alpha$) reactions to the ground states of the respective residual nuclei. A DWBA analysis was used to fit the (p,d) experimental data, and relative spectroscopic factors were extracted. The $^{7}Li(p,pd)^{3}He$ angular correlation was studied; the results were compared with those obtained for the $^{7}Li(p,pd)^{4}He$ reaction at the same energy. (auth)

**19182** ELECTROEXCITATION OF THE 10.8-MeV ($1^-$; T = 0) LEVEL OF $^{12}C$ AND THE 7.12-MeV ($1^-$; T = 0) LEVEL OF $^{16}O$. Torizuka, Y.; Oyamada, M.; Nakahara, K.; Sugiyama, K.; Kojima, Y.; Terasawa, T.; Itoh, K.; Yamaguchi, A.; Kimura, M. (Tohoku Univ., Sendai). Phys. Rev. Lett., 22: 544-6(Mar. 17, 1969).

Form factors for E1 ($\Delta T = 0$) electroexcitation of the 10.8-MeV level of $^{12}C$ and the 7.12-MeV level of $^{16}O$ were obtained from inelastic electron scattering experiments. These form factors showed an anomalous q dependence relative to the usual E1 electroexcitation. (auth)

**19183** INVESTIGATION OF COLLISION TIMES IN ELASTIC SCATTERING OF PARTICLES. Olkhovskii, V. S.; Sokolov, L. S.; Zaichenko, A. K. (Kiev State Univ.). Yadern. Fiz., 9: 190-2 (Jan. 1969). (In Russian).

Collision times calculated by means of Wigner's method are presented for the elastic scattering of 6.8-MeV neutrons, 6.8-MeV protons, and 13.6-MeV deuterons on the nuclei $^{12}C$, $^{40}Ca$, $^{52}Cr$, $^{60}Ni$, $^{63}Cu$, $^{209}Bi$. The scattering amplitudes required for the calculations were obtained using the optical model. (auth)

**19184** REACTIONS OF $^{16}O(\pi^+,\pi^+)4\alpha$ AT $\pi^+$ MESON ENERGY OF 117 MeV. Kosmach, V. F.; Ostroumov, V. I. Yadern. Fiz. 9: 224(Jan. 1969). (In Russian).

The reaction $^{16}O(\pi^+,\pi^+)4\alpha$ was studied at 117 MeV using nuclear emulsions. The cross section was found to be $8.0 \pm 1.5 \times 10^{-27}$ cm$^2$. The data were analyzed using the pole approximation. It was concluded that strong $\alpha$-particle interaction occurred in the final state and that the contribution of the pole diagrams was not a decisive factor. (R.V.J.)

**19185** RADIATIVE NEUTRON CAPTURE BY HOLE NUCLEI. Kolomiets, V. M. (Inst. of Physics, Kiev). Yadern. Fiz., 9: 63-8(Jan. 1969). (In Russian).

The mechanism of radiative neutron capture with excitation of particle-hole intermediate states was considered. Radiative and neutron widths of the states were calculated in the framework of the shell model with residual interaction. Contributions from both resonance and direct mechanisms of the capture were taken into account in the calculation of the total capture cross section. Calculations were carried out for the reaction $^{15}O(n,\gamma)^{16}O$ in the neutron energy interval $E_n$ = 0 to 10 MeV. (auth)

**19186** STUDY OF THE MECHANISM OF THE REACTION $^{12}C(\gamma,n)^{11}C$ BY THE RECOIL NUCLEI METHODS AT THE PHOTON ENERGY UP TO 260 MeV. Denisov, F. P.; Duisebaev, A.; Cherenkov, P. A. (Lebedev Inst. of Physics, Moscow). Yadern. Fiz., 9: 3-8(Jan. 1969). (In Russian).

By means of registration of radioactive recoil nuclei, angular and energy distributions of $^{11}C$ nuclei were investigated which were produced in the reaction $^{12}C(\gamma,n)^{11}C$ under the action of bremsstrahlung with a maximum energy of 260 MeV center-of-mass angular distributions of recoil nuclei produced in this reaction were satisfactorily described by curves of the type $1 + \alpha_1 \sin^2\theta' + \beta_1 \sin^2\theta' \cdot \cos\theta'$. It is shown that a small yield of the recoil nuclei with kinetic energies greater than 2.27 MeV is peculiar for the energy distributions. The mean excitation of the $^{11}C$ nucleus is 0 to 5 MeV in the region of the giant resonance and increases up to 30 MeV with the $\gamma$ quanta energy. (auth)

**19187** RESONANCE ENERGY AND YIELD MEASUREMENTS WITH A Ge(Li) DETECTOR. Kurtz, E. (Univ. of Oregon, Eugene); Battleson, K.; McDaniels, D. K.; Horen, D. J. Nucl. Instrum. Methods, 69: 56-60(Mar. 1969).

Two simple innovations for measurement of resonance energies and yields have been tested using the $^{27}Al(p,\gamma)^{28}Si$ reaction. The first involves the use of a thick (several keV) target and simultaneous excitation of resonances over a broad energy range, while the second uses a thin (20-keV) target and single resonances are excited successively. Both methods exploit the high resolution of a Ge(Li) detector and the excellent linearity and gain stability of the associated electronics. Experiments testing the thick target technique have given several calibration points in the $E_p$ = 1- to 2.5-MeV range with an accuracy better than ±0.7 keV. Resonance values utilizing thin targets compare well with previous results for proton energies less than 1.5 MeV and are more accurate than previously reported values for some resonance energies between 1.5 and 2.5 MeV. Yield results from both methods compare with each other and with previous results within about 30%. (auth)

**19188** PRELIMINARY EXPERIMENTAL RESULT ON THE MEAN LIFETIME OF THE 10.94-MeV STATE OF $^{16}O$. Filosofo, I. (Univ., Padua. Istituto Nazionale di Fisica Nucleare, Padua); Fuschini, E.; Maroni, C.; Uguzzoni, A.; Verondini, E. Nuovo Cim., Lett., 1: 349-51(Feb. 21, 1969).

The mean life of the 10.94-MeV level in $^{16}O$ was measured to be $0.50 \pm 0.25 \times 10^{-13}$ sec by observing $\gamma$ singles and coincidence spectra from the reaction $^{14}N(^3He,p)^{16}O$ at 4 MeV. (D.C.W.)

**19189** SEARCH FOR A T = 2 STATE IN FOUR-NUCLEON SYSTEM. Goldberg, V. Z.; Ogloblin, A. A.; Rudakov, V. P. (Inst. of Atomic Energy, Moscow). Yadern. Fiz., 9: 16-18(Jan. 1969). (In Russian).

No T = 2 level of $^4Li$ was detected in the reaction $^7Li(^3He,^6He)^4Li$. The cross section was less than $1.10^{-30}$ cm$^2$/sterad. (auth)

**19190** REACTIONS ($\pi^-$,NN) AND STRUCTURE OF Li NUCLEI. Kopaleishvili, T. I.; Machabeli, I. Z. (Tbilisi State Univ., USSR). Yadern. Fiz., 9: 87-93(Jan. 1969). (In Russian).

A unified theoretical calculation was carried out for ($\pi^-$,2n) and ($\pi^-$,np) reactions on $^6Li$ and $^7Li$. Angular and energy distributions of emitted nucleons, the excitation spectrum of the residual nuclei, the ratio of the yields of nn and np, and the ratio of the probability of the ground state for the residual nucleus to the total probability, are calculated. The results are compared with available experimental data. (auth)

**19191** THE ($\pi^-$,nn) REACTION AT REST ON $^6Li$, $^9Be$, AND $^{12}C$ NUCLEI. Calligaris, F. (Univ., Trieste, Italy. Istituto Nazionale di Fisica Nucleare, Trieste, Italy); Cernigoi, C.; Gabrielli, I.; Pellegrini, F. Nucl. Phys., A126: 209-24(1969).

The absorption of negative pions at rest in $^6Li$, $^9Be$ and $^{12}C$ nuclei was investigated by the study of energy spectra and the momentum distributions of two neutrons, emitted at a correlation angle around 180°. A time-of-flight technique was used for the determination of the energy and the momentum of the neutrons. (auth)

**19192** ELASTIC AND INELASTIC SCATTERING OF HIGH-ENERGY ELECTRONS IN THE CLUSTER MODEL. Kudeyarov, Yu. A.; Kurdyumov, I. V.; Neudatchin, V. G.; Smirnov, Yu. F. (Moscow State Univ.). Nucl. Phys., A126: 36-48(1969).

The use of the cluster model permits a uniform description of a number of form factors of electric and magnetic, elastic and inelastic (with excitation of lower levels) high-energy electron scattering on many of the lightest nuclei. Analysis of the results shows that in the case of $^6Li$ the clusters are very isolated. Isolation of clusters is reduced with increasing atomic number but remains noticeable for such nuclei as $^{12}C$ and $^{16}O$. When the cluster isolation is considerable the Pauli principle little affects the form factors ($^6Li$), but already for $^7Li$ and heavier nuclei inclusion of Pauli principle appears to be important. The results are compared with calculations on the basis of other models (shell model, random phase approximation, Hartree-Fock method) and with experiment. On the assumption that in the state $0^+$(7.66 MeV) the nucleus $^{12}C$ is a linear chain of three $\alpha$-clustors one can also describe the cross section of inelastic electron scattering with excitation of this level as well as its decay widths with respect to emission of electron-positron pairs ($\Gamma_{e^\pm}$) and quadrupole emission ($\Gamma_{E2}$). (auth)

**19193** REACTION (p,d) AT 156 MeV AND THE STRUCTURE OF LIGHT NUCLEI. Bachelier, D.; Bernas, M.; Brissaud, I.; Detraz, C.; Radvanyi, P. (Institut de Physique Nucleaire, Orsay, France). Nucl. Phys., A126: 60-96(1969). (In French).

Energy spectra and angular distributions were measured with a magnetic spectrometer for the following pick-up reactions at 156 MeV: $^6Li(p,d)^5Li$; $^7Li(p,d)^6Li$; $^9Be(p,d)^8Be$; $^{10}B(p,d)^9Be$; $^{11}B(p,d)^{10}B$; $^{12}C(p,d)^{11}C$; $^{16}O(p,d)^{15}O$; $^{28}Si(p,d)^{27}Si$ and $^{40}Ca(p,d)^{39}Ca$. It is shown that, at this energy, where the separation between levels is small compared to the energies of the incoming and outgoing particles, the PWBA without cut-off radius, although not being able to reproduce the experimental angular distributions, allows a good extraction of the relative spectroscopic factors $F^2$ for a given l. The $F^2$ values agree quite well with those calculated for 1p shell nuclei with the wave functions of Cohen and Kurath and of Boyarkina; the agreement is in general also good with the $F^2$ extracted by DWBA at various energies. The ratio between the absolute $F^2$ obtained by PWBA and the theoretical $F^2$ might be considered as a distortion factor, which is a function of angle $\theta$; it appears that this factor does not vary much throughout the 1p shell. The pick-up in the inner major shell is discussed: the cross section for simple 1s pick-up decreases sharply when going from $^4He$ to $^6Li$ target nuclei; a similar effect appears for 1p pick-up between $^{16}O$ and $^{19}F$; this behavior, probably related to the high neutron momenta involved, is not yet well understood. (auth)

**19194** INVESTIGATION OF THE REACTIONS $^7Li(p,p_0)^7Li$ $^7Li(p,p_1)^7Li^*$, AND $^7Li(p,\alpha)^4He$ WITH POLARIZED PROTONS OF ENERGIES 2.7 TO 10.6 MeV. Kilian, K.; Clausnitzer, G.; Duerr, W.; Fick, D.; Fleischmann, R.; Hofmann, H. M. (Univ., Erlangen Nuernberg, Ger.). Nucl. Phys., A126: 529-44(1969). (In German).

Differential cross sections and analyzing powers of the $^7Li(p,p_0)$ $^7Li$, $^7Li(p,p_1)^7Li^*$ and $^7Li(p,\alpha)^4He$ reactions were measured with polarized protons. The measured angular distributions are expanded into Legendre polynomials. The energy dependence of the expansion coefficients contains additional information about levels in $^8Be$. (auth)

**19195** STUDY OF (p,$\alpha$) REACTIONS IN LIGHT NUCLEI AT 38 MeV. Gambarini, G.; Iori, I.; Micheletti, S.; Molho, N.; Pignanelli, M.; Tagliaferri, G. (Univ., Milan. INFN, Milan). Nucl. Phys., A126: 562-76(1969).

Differential cross sections for (p,$\alpha$) reactions at $E_p$ = 38 MeV were obtained for $^9Be$, $^{11}B$, $^{12}C$, $^{16}O$, and $^{19}F$. Some angular distributions show a well-developed diffraction pattern, others do not. The results were compared with PWBA calculations for four direct mechanisms (pick-up, knock-out, heavy-particle pick-up and heavy-particle knock-out). No single mechanism seems able to reproduce the pattern of any observed distribution for the whole angular range investigated. (auth)

**19196** STUDY OF THE REACTION $^9Be(^3He,^6Li)^6Li$. Taylor, M. C.; Phillips, G. C. (Rice Univ., Houston, Tex.). Nucl. Phys., A126: 615-27(1969).

The reaction $^9Be(^3He, ^6Li)^6Li$ was studied at bombarding energies up to 10 MeV. The $^6Li$ particles were identified by an associ-

ated particle time-of-flight technique in which the mass of one particle is determined from the product of its energy and flight-time squared, $ET^2$. Angular distributions at 6, 7, 8 and 10 MeV along with an excitation function at a laboratory angle of 50° were measured using $^6$Li-$^6$Li coincidence. The angular distribution data indicate that high angular-momentum transfer (l = 3 and 4) is involved at the higher energies. Observed cross sections of the order of 5 mb total are surprisingly large in view of the high angular momentum transfer. (auth)

**19197** EFFECTS OF RESONANCES IN $^{12}$C ON THE EMISSION OF $\alpha$ PARTICLES IN THE REACTION $^{11}$B(p,3$\alpha$). Quebert, J. L.; Marquez, L. (Univ., Bordeaux). Nucl. Phys., A126: 646-70(1969). (In French).

The following $\alpha$-particle spectra from the reaction $^{11}$B(p,3$\alpha$) were measured: single spectra for $E_p$ = 0.15 to 4.0 MeV and coincidence spectra at the $E_p$ = 675 keV resonance. The results can be explained with a formula that takes into account the spin and parity of the compound nucleus $^{12}$C and the well-known properties of the intermediate state $^8$Be(2$^+$). This formula explains the variations in shape with the $^{12}$C spin and parity, the apparent narrow width of the $^8$Be(2$^+$) state for some resonances and the forbidden regions in the Dalitz plot. (auth)

**19198** ANGULAR DISTRIBUTION OF RECOIL NUCLEUS FROM PARTIALLY POLARIZED MUON CAPTURE BY THE NUCLEUS OF NONZERO SPIN. Kyiv, M.; Palgi, L. Tr. Inst. Fiz. Astron., Akad. Nauk Est. SSR, No. 33, 77-87(1967). (In Russian).

General formulas for the asymmetry coefficient are presented. Unique transformations are considered in detail. Experimental study of recoils from muon capture in $^6$Li ought to give a new possibility to detect the pseudoscalar constant of muon capture almost independently from the nuclear model. (auth)

## Nuclear Properties and Reactions, 20 ≤ A ≤ 89

*Refer also to abstracts 17747, 17777, 18396, 18821, 19026, 19159, 19174, 19175, 19183, 19193, 19248, 19250, 19253, 19254, 19264, 19309, 19319, 19349, 19351, 19367, 19368, 19384, and 19385.*

**19199** (ANU-P/427) OPTICAL MODEL ANALYSIS OF 29-MeV $^3$He DIFFERENTIAL CROSS SECTION AND TOTAL REACTION CROSS SECTION DATA. Baugh, D. J. (Australian National Univ., Canberra. Dept. of Nuclear Physics). [1969]. 37p. Dep.

Differential cross sections and total reaction cross section measurements for $^3$He ions scattered by Mg, Al, $^{56}$Fe, $^{63}$Cu, and Ag targets were analyzed using the optical model. Discrete and continuous ambiguities are discussed. The inclusion of reaction cross section measurements did not significantly resolve these ambiguities. (auth) (Australia)

**19200** (COO-1468-3) PROGRESS REPORT [ON NUCLEAR PHYSICS], JANUARY 1–DECEMBER 31, 1968. [Donahue, Douglas J.; McCullen, John D.; McIntyre, Laurence C. Jr.] (Arizona Univ., Tucson). Jan. 1969. Contract AT(11-1)-1468. 14p. Dep. CFSTI.

Doppler-shift measurements of the lifetimes of levels in $^{20}$F, $^{25}$Mg, $^{27}$Mg, $^{29}$Si, $^{31}$Si, and $^{33}$S were made; and a target chamber was developed for Doppler-shift measurements. A program for measuring nuclear level spins and multipole mixing ratios in gamma transitions were initiated; a target chamber for measuring particle-gamma angular correlations from nuclear reactions was developed. Development of the polarized ion source for the CN Van de Graaff accelerator continued. Measurements were made on the reactions $^{49}$Ti(p,n$\gamma$)$^{49}$V and $^{50}$Ti(p,n$\gamma$)$^{50}$V; new gamma transitions were observed. The time resolution of the particle-gamma fast coincidence system was improved from 60 to 20 nanosec FWHM. (D.C.W.)

**19201** (INP-614) GLORY EFFECT IN THE OPTICAL MODEL ANALYSIS OF THE $^{39}$K($\alpha$,$\alpha$)$^{39}$K ELASTIC SCATTERING. Budzanowski, A.; Dudek, A.; Dymarz, R.; Grotowski, K.; Jarczyk, L.; Niewodniczanski, H.; Strzalkowski, A. (Institute of Nuclear Physics, Krakow (Poland). Jagellonian Univ., Krakow (Poland). Inst. of Physics). July 1968. 23p. Dep.

An optical model analysis of the $^{39}$K($\alpha$,$\alpha$)$^{39}$K scattering data in the wide angular range up to 179° and for nine different energies of alpha particles from 22.1 to 28.2 MeV was done in order to investigate whether the so called nuclear glory effect is contained in the optical model. Six 4-parameter potentials describing elastic scattering were found with the depth of the real part ranging from 100 MeV to 300 MeV. Only the potentials with the real part deeper than 200 MeV can reproduce the backward scattering. The radius parameters corresponding to these deep potentials are rather small ($r_0$ = 1.1 fm). It was shown in an additional study that partial waves corresponding to the surface region of the target nucleus play an essential role for the backward scattering. (auth)

**19202** (NP-17769) EFFECT OF CORE PARTICLE-HOLE EXCITATIONS ON PROPERTIES OF VIBRATIONAL STATES. Gillet, Vincent; Giraud, Bertrand; Rho, Mannque (Commissariat a l'Energie Atomique, Saclay (France). Centre d'Etudes Nucleaires). [1968]. 8p. Dep.

Calculations were performed for the energy levels and transition probabilities for single closed-shell nuclei using 2-quasiparticle configurations mixed with 1p–1h core configurations. Input data were extruded from neighboring odd-A nuclei in order to keep the number of adjustable parameters low. Good agreement was obtained for the odd-parity states, but the even-parity states appear to be of a more complicated nature than is suggested by 2-quasiparticle plus core p–h configurations. (J.W.R.)

**19203** (PUC-937-339) PROTON DECAY OF ISOBARIC ANALOGUE STATES FROM THE (p,n) REACTION IN NUCLEI WITH A = 67 TO 125. Miller, Peter S. (Princeton Univ., N. J. Palmer Physical Lab.). Aug. 1968. Contract AT(30-1)-937. 151p. Dep. CFSTI.

Thesis.

The isobaric analog states of the ground states of $^{67}$Zn, $^{77}$Se, $^{91}$Zr, $^{95,97}$Mo, $^{105}$Pd, $^{110,111,113}$Cd and $^{115,116,117,119}$Sn, and $^{123,125}$Te were studied by the (p,n) charge-exchange reaction, using isotopically enriched targets of the above nuclides. The proton decay ($\bar{p}$) of the analog state was observed using solid-state detectors in a particle identifier configuration. Absolute cross sections for the (p,n$\bar{p}$) reaction are presented. An estimate of the amplitudes for mixing between the analog configuration and nearby levels having different isotopic spin shows that gamma-decay of the analog may compete significantly and observably with the proton decay mode in some cases where neutron decay is impossible. For certain targets ($^{91}$Zr, $^{95}$Mo, $^{115}$Sn) whose analog states have no neutron decays, the (p,n) cross sections were calculated in the distorted-wave Born approximation, using a consistent, charge-independent formalism. The results were compared with the measured (p,n$\bar{p}$) cross sections. The observed energy dependence of the cross sections is related to a variation with energy of the imaginary potential for the outgoing neutrons. (auth)

**19204** (RPI-3948-1) DECAY PROPERTIES OF NEUTRON EXCESS ISOTOPES. Technical Progress Report, April 1, 1967-December 31, 1968. Preiss, I. L.; Clark, H. M. (Rensselaer Polytechnic Inst., Troy, N. Y. Dept. of Chemistry). Jan. 1969. Contract AT(30-1)-3948. 8p. Dep. CFSTI.

The half-lives and $\gamma$ energies of $^{40}$Cl, $^{42}$K, $^{43}$K, $^{46}$Sc, $^{47}$Sc, $^{48}$Sc, and $^{48}$V formed in photonuclear reactions on $^{51}$V were measured, together with integrated cross sections for the various photonuclear processes. The decay scheme of $^{56}$Ni from the reaction $^{58}$Ni($\gamma$,2n)$^{56}$Ni was investigated; evidence for two closely spaced levels at about 1.0 MeV in $^{56}$Co was obtained. Photonuclear reactions on Gd were investigated by irradiating samples of $Gd_2O_3$ at electron beam energies up to 50 MeV. The decay schemes of $^{124}$Ba-$^{124}$Cs were investigated. (D.C.W.)

**19205** RELATIVE YIELDS OF $^{58g}$Co, $^{58m}$Co, AND $^{56}$Co PRODUCED BY LOW-ENERGY TRITONS. Kiefer, R. L.; Hillman, Manny (Brookhaven National Lab., Upton, N. Y.). J. Inorg. Nucl. Chem., 31: 915-17(Apr. 1969).

The relative yields of the $^{56}$Fe(t,n) $^{58m}$Co, $^{58g}$Co and $^{54}$Fe(t,n)$^{56}$Co reactions were studied using 2.73-MeV tritons. This study was made in an effort to determine the effect of intrinsic spin differences between target and product nuclides in a reaction induced by a low-energy charged particle. The spin changes necessary to produce $^{58m}$Co and $^{58g}$Co from $^{56}$Fe are 5 and 2, respectively. A spin change of 4 is necessary to proceed from $^{54}$Fe to $^{56}$Co. The results showed that production of the nuclide with the lowest spin was favored. The relative yields were: $\sigma(^{58g}\text{Co})/\sigma(^{58m}\text{Co}) = 3.3 \pm 0.1$, and $\sigma(^{58g}\text{Co})/\sigma(^{56}\text{Co}) = 4.8 \pm 0.2$. (auth) (UK)

**19206** A SYSTEMATIC STUDY OF FAST NEUTRON ELASTIC SCATTERING IN THE ENERGY REGION 1.5 TO 8.1 MeV. Holmqvist, B. (Aktiebolaget Atomenergi, Studsvik, Sweden). Ark. Fys., 38: 403-65(1968).

Fast neutron elastic scattering was studied in the energy range 1.5 to 8.1 MeV from Al, S, Ca, Cr, Mn, Fe, Co, Ni, Cu, Zn, In, and Bi by the time-of-flight technique. Angular distributions were obtained for these elements by observing the neutron scattering at several angles between 20 and 160°. The differential elastic cross sections were determined relative to the well-known neutron cross sections for proton and carbon. The experimental angular distribu-

tions were corrected for the anisotropy of the neutron source, attenuation of the neutron flux in the scatterer, neutron multiple scattering, and the finite source-sample-detector geometry using a Monte Carlo computer program. The comprehensive and homogeneous experimental material was used for a systematic study of the nuclear optical model. Theoretical angular distributions were fitted to the experimental data using a local central optical potential consisting of Saxon–Woods, derivative Saxon–Woods, and Thomas form factors describing the real, imaginary, and spin-orbit potentials, respectively. Optimum values of the real and imaginary potential depths, the corresponding nuclear radii, and the real potential diffuseness parameter were calculated independently for each element and energy with an automatic parameter search program. Very good agreements were obtained between the experimental and theoretical angular distributions. The optical model parameters were found to be essentially independent of the neutron energy except for the even mass number elements for which the real potential depth slowly decreases with the energy. From the mass number dependence of the real and imaginary potential depths evidence was obtained for a real isobaric spin potential as well as an indication of a corresponding imaginary potential. The strengths of these potentials are 50 ± 15 MeV and 100 ± 30 MeV, respectively. The real diffuseness parameter was demonstrated to be essentially mass independent. Its mean value is 0.66 ± 0.01 fm taking all measurements into account. Indications were obtained that the real and imaginary radii do not follow the simple expression $R = r_0A^{\frac{1}{3}}$ assumed in the constant density nuclear model. The parameter $r_0$ of the real and imaginary radii slowly increases with the mass number. The neutron root-mean-square radii calculated with the real potential geometrical parameters were shown to be in excellent agreement with the corresponding radii calculated with geometrical parameters from proton elastic scattering at 11, 17, 30, and 40 MeV. Furthermore, the extension of the matter and charge distributions were calculated for a number of nuclei from neutron and electron root-mean-square radii showing that the mass distribution extends beyond that of the nuclear charge distribution. The difference between the root-mean-square matter and charge radii is also shown to increase somewhat with the neutron excess in nuclei. (auth) (Sweden)

**19207** GAMMA RAYS FROM $^{70,72}$Ge(p,p′γ) REACTIONS. Mohindra, R. K. (Kurukshetra Univ., India); Van Patter, D. M. Proc. Nucl. Phys. Solid State Phys. Symp., 1968, Madras, 396-400(1968).

Protons of 5- to 7-MeV energy were inelastically scattered from enriched targets of $^{70}$Ge and $^{72}$Ge. The angular distributions of γ rays were studied using two NaI(Tl) detectors. Also the γ spectra from $^{70}$Ge was measured at 90° with a Ge(Li) detector. Spin-parity assignments were determined for the higher levels excited in the reaction. (J.W.R.)

**19208** ANALYSIS OF EXCITATION FUNCTIONS FOR THE $^{27}$Al(p,α$_0$)$^{24}$Mg AND $^{27}$Al(p,α$_1$)$^{24}$Mg* REACTIONS. Mehta, M. K.; Divatia, A. S. (Bhabha Atomic Research Centre, Trombay, India). Proc. Nucl. Phys. Solid State Phys. Symp., 1968, Madras, 368-70(1968).

The excitation functions for the $^{27}$Al(p,α$_0$)$^{24}$Mg and $^{27}$Al(p,α$_1$)$^{24}$Mg* reactions at 4.0 to 5.5 MeV were measured at the laboratory angles of 60, 90, and 165°. The curves show fine structure of 20-keV order superimposed on 100 to 300 keV structure. The angular and channel cross correlations were calculated and an explanation for the structure is offered. (J.W.R.)

**19209** ANALYSIS OF PROTON SPECTRA FROM (n,p) REACTIONS AT 14 MeV INCIDENT NEUTRON ENERGY. Singh, Jahan; Hans, H. S. (Punjab Univ., Chandigarh, India). Proc. Nucl. Phys. Solid State Phys. Symp., 1968, Madras, 241-3(1968).

From Nuclear Physics and Solid State Physics Symposium, Madras, India. See CONF-680212.

The proton spectra and angular distributions of protons from a large group of (n,p) reactions at 14 MeV were analyzed in an attempt to separate out the compound and direct reaction parts. (J.W.R.)

**19210** SPIN AND PARITY ASSIGNMENT TO THE LEVEL AT 14.378 MeV IN $^{28}$Si. Kerekatte, S. S.; Balakrishnan, M.; Mehta, M. K.; Divatia, A. S. (Bhabha Atomic Research Centre, Trombay, India). Proc. Nucl. Phys. Solid State Phys. Symp., 1968, Madras, 221-3(1968).

From Nuclear Physics and Solid State Physics Symposium, Madras, India. See CONF-680212.

A shape analysis was performed for the 5.13-MeV resonance in alpha elastic scattering by 24 Mg. A tentative assignment of $J^\pi = 4^+$ was made to the 14.38-MeV level in $^{28}$Si. (J.W.R.)

**19211** CORE EXCITATION IN (d,p) STRIPPING. McCarthy, I. E.; Pal, Dipti (Univ. of Oregon, Eugene). Proc. Nucl. Phys. Solid State Phys. Symp., 1968, Madras, 224-8(1968).

From Nuclear Physics and Solid State Physics Symposium, Madras, India. See CONF-680212.

The angular distributions for the $^{44}$Ca(d,p)$^{45}$Ca reactions were calculated by the DWBA method with a deuteron-core residual interaction. (J.W.R.)

**19212** SHELL MODEL FOR A = 21, 22 NUCLEI. Pandya, S. P. (Physical Research Lab., Ahmedabad, India). Proc. Nucl. Phys. Solid State Phys. Symp., 1968, Madras, 185-7(1968).

Shell-model calculations were performed for A = 21 and 22 nuclei using an effective interaction. The full s-d shell configuration space was used to generate the wavefunctions. Level schemes were determined for $^{21}$F, $^{21}$Ne, and $^{22}$Na. (J.W.R.)

**19213** ELASTIC AND INELASTIC SCATTERING OF 6-MeV PROTONS ON $^{59}$Co AND THE EXCITED-CORE MODEL. Antropov, A. E.; Gridnev, K. A.; Zarubin, P. P.; Orlov, B. N.; Plavko, A. V.; Sorokin, A. I. Izv. Akad. Nauk SSSR, Ser. Fiz., 32: 1747-53(Oct. 1968). (In Russian).

Elastic and inelastic scattering of 6-MeV protons on $^{60}$Co was studied in order to determine the mechanism of the scattering process and to investigate the applicability of the excited-core model for describing the states of $^{59}$Co nuclei of excitation energies up to 2 MeV. The results showed that in proton inelastic scattering on $^{59}$Co the contribution of indirect processes averages 50% for excitation of levels up to 1.5 MeV and up to 100% for excitation of levels above 2 MeV. The core-excitation model presents a good approximation for the lower-lying states. The applicability of the model for describing $^{59}$Co states on the basis of integral inelastic scattering cross sections proved to be indeterminate due to the interference of indirect processes. (R.V.J.)

**19214** CROSS SECTION OF THE $^{27}$Al(n,α)$^{24}$Na REACTION IN THE ENERGY REGION FROM 13.8 MeV TO 14.8 MeV. Boschung, P.; Gagneux, St.; Huber, P.; Steiner, E.; Wagner, R. (Univ., Basel). Helv. Phys. Acta, 42: 252-4(Apr. 1, 1969). (In German).

The total $^{27}$Al(n,α)$^{24}$Na reaction cross section was measured in the energy range of 13.8 to 14.8 MeV using the activation method. The results are in good agreement with data of other recently published measurements. The absolute value of the total cross section at 14.2 MeV was determined to be 120 ± 5 mb. (auth)

**19215** MEASUREMENT OF THE NEUTRON POLARIZATION PROBABILITY OF THE ELEMENTS Mg, Al, Si, AND S FOR THE MEAN NEUTRON ENERGY $E_n$ = 3.25 MeV. Wiedemann, K.; Baumgartner, E.; Ellgehausen, D.; Gleyvod, R.; Huber, P. (Univ., Basel). Helv. Phys. Acta, 42: 259-68(Apr. 1, 1969). (In German).

The analyzing power $P^a(\theta)$ of Mg, Al, Si, and S in the angular range from 30 to 140° was measured for (d,d) neutrons of mean energy 3.25 MeV with spread of 300 keV. The polarization vector of the incident neutron beam was rotated through ±90° by means of a solenoid, and the left-right asymmetry was measured with a fixed counter position. The experimental results disagree with optical model predictions. (auth)

**19216** STUDY OF NUCLEAR STRUCTURE BY (t,nγ) AND (p,γ) REACTION. Sekiguchi, Hiroyoshi (Tokyo Univ.). J. Phys. Soc. Jap., 26: 589-99(Mar. 1969).

The level schemes of $^{50}$V, $^{54}$Mn, $^{58}$Co, and $^{57}$Fe were investigated with the Ge(Li) detectors and the scintillation counters by using triton-induced reactions. These results were also compared with (p,γ) reactions. Gamma rays at energies of 92, 122, 158, and 225 keV on $^{50}$V; 55, 156, 212, and 250 keV on $^{54}$Mn; 112 and 367 keV on $^{58}$Co were observed. By using the residual activities, the reaction characteristics of the triton induced reaction were investigated. The spin distribution in the $^{55}$Mn(t,n)-$^{57}$Fe reaction was calculated with the compound-nucleus model and the ratio of the population probability obtained is $^5/_9$ for the $J = {}^1/_2$ and $J = {}^5/_2$ states on $^{57}$Fe. New gamma rays which expected from the rotational model on $^{57}$Fe were searched for with this reaction, but they were not observed. (auth)

**19217** ELASTIC SCATTERING OF POLARIZED NEUTRONS OF 3.25 MeV ON MEDIUM-HEAVY NUCLEI. Ellgehausen, D.; Baumgartner, E.; Gleyvod, R.; Huber, P.; Stricker, A.; Wiedemann, K. (Univ., Basel). Helv. Phys. Acta, 42: 269-83(Apr. 1, 1969). (In German).

Angular distributions of the azimuthal asymmetry of elastically scattered polarized neutrons were measured between 30 and 140° for the six elements titanium, chromium, iron, copper, zinc, and zirconium. As a source of polarized neutrons the D(d,n)$^3$He reaction in a thick ice target was used (mean neutron energy: 3.25 MeV). The asymmetry was measured with fixed counter position by rotating the polarization of the incident neutron beam through an angle of ±90° by means of an axial magnetic field. The overall behavior of the analyzing power of the above ele-

ments with the exception of zirconium could be described using an optical model potential with parameters found by Rosen, whereas the maximum measured value of the latter was about a factor of three higher than that predicted by the model. (auth)

**19218** THE (d,p) REACTION IN $^{27}$Al AT 2 MeV. Ahmed, R. (Univ. of Dacca, Pakistan); Sen Gupta, H. M.; Awal, M. A.; Mohsin, M. Nucl. Sci. Appl., Ser. B, 4: 22-4(Oct. 1968).

The (d,p) reaction was studied in natural Al with a beam of 2-MeV deuterons by using a nuclear plate camera. The Q-value of the reaction leading to the unresolved ground and first excited states in $^{28}$Al was found to be 5.43 ± 0.13 MeV; the angular distribution of protons was measured for this process over a range 32.5 to 150° (lab) and was fitted by the Legendre polynomial expansion. (auth)

**19219** HALF-LIVES OF SOME SHORT-LIVED MASS-SEPARATED GASEOUS FISSION PRODUCTS AND THEIR DAUGHTERS. Carlson, G. C.; Schick, W. C. Jr.; Talbert, W. L. Jr.; Wohn, F. K. (Ames Lab., Iowa). Nucl. Phys., A125: 267-75(1969).

The half-lives of several short-lived isotopes of Kr, Rb, Sr, Xe, Cs, and Ba were measured using sources of isotopically pure Xe or Kr and multi-scaling selected transitions in the Ge(Li) gamma-ray spectra of their decays. Beta-ray multi-scaling was employed to confirm the gamma-ray multi-scaling results in several cases. The results of the measurements are (in sec) $^{89}$Kr, 190.7 ± 1.4; $^{89}$Rb, 909 ± 7; $^{90}$Kr, 32.32 ± 0.09; $^{90}$Rb, 153 ± 3 and 251 ± 10; $^{91}$Kr, 8.57 ± 0.04; $^{91}$Rb, 58.2 ± 0.2; $^{92}$Kr, 1.840 ± 0.008; $^{92}$Rb, 4.50 ± 0.03; $^{93}$Kr, 1.289 ± 0.012; $^{93}$Rb, 5.86 ± 0.13; $^{93}$Sr, 439 ± 6; $^{137}$Xe, 229.1 ± 0.8; $^{138}$Xe, 850 ± 4; $^{138}$Cs, 1932 ± 12; $^{139}$Xe, 39.68 ± 0.14; $^{139}$Cs, 556 ± 3; $^{140}$Xe, 1360 ± 0.10; $^{140}$Cs, 63.7 ± 0.3; $^{141}$Xe, 1.720 ± 0.013; $^{141}$Cs, 24.7 ± 0.4; $^{141}$Ba, 1096 ± 4; $^{142}$Xe, 1.24 ± 0.02; $^{142}$Cs, 1.68 ± 0.02, and $^{142}$Ba, 639 ± 7. The existence of an isomeric state in $^{90}$Rb is indicated by the results of spectrum multi-scaling. In most cases, these results compare favorably with recently published values of these half-lives. (auth)

**19220** DECAY OF 22-min $^{44}$K. Taylor, H. W.; King, J. D.; Ing, H.; Cox, R. J. (Univ. of Toronto). Nucl. Phys., A125: 358-68(1969).

The gamma rays emitted during the decay of $^{44}$K were investigated with a 20 cm$^3$ Ge(Li) detector. A total of 20 gamma rays was identified with energies (intensities) of 367(4), 643(2), 651(5), 683(1), 727(10), 749(5), 877(4), 1015(6), 1024(12), 1127(16), 1156.8(100), 1498(18), 1752(7), 2150(34), 2507(4), 2519(12), 2656(6), 3394(≈5), 3622(≈11) and 4868(≈0.5) keV. Of these, all but one were incorporated into a level scheme for $^{44}$Ca which is in good agreement with the schemes suggested by (d,p), (p,p′), and (α,α′) reaction experiments. (auth)

**19221** STUDY OF LEVELS IN $^{24}$Mg BY THE $^{23}$Na(d,n)$^{24}$Mg REACTION. Tang, S. M.; Sowerby, B. D.; Sheppard, D. M. (Univ. of Alberta, Edmonton). Nucl. Phys., A125: 289-304 (1969).

Neutron time-of-flight spectra from the $^{23}$Na(d,n)$^{24}$Mg reaction were measured at $E_d$ = 5.5 MeV. Angular distributions of transitions to 20 states in $^{24}$Mg up to 12.7 MeV excitation energy were analyzed with DWBA and Hauser–Feshbach theory to yield $l_p$ values and absolute spectroscopic factors. The spins and parities of the $^{24}$Mg states at 7.75 and 8.86 MeV were found to be 1$^+$ and 2$^-$, respectively. The T = 1 isobaric analogue states were identified at 9.52, 10.07, 10.74, 11.22, 12.53, and 12.67 MeV, the latter two being the previously unobserved analogues of the $^{24}$Na states at 3.41 and 3.37 MeV, respectively. From the isobaric analogue identification, probable spins and parities of several $^{24}$Na states were deduced. The experimental spectroscopic factors for stripping to the six lowest-lying $^{24}$Mg states show rather poor agreement with the Nilsson model predictions. (auth)

**19222** GLORY EFFECT IN THE OPTICAL-MODEL ANALYSIS OF $^{39}$K(α,α)$^{39}$K ELASTIC SCATTERING. Budzanowski, A.; Dudek, A.; Dymarz, R.; Grotowski, K.; Jarczyk, L.; Niewodniczanski, H.; Strzalkowski, A. (Inst. of Nuclear Physics, Krakow. Jagellonian Univ., Krakow). Nucl. Phys., A126: 369-80(1969).

An optical-model analysis of the $^{39}$K(α,α$_0$)$^{39}$K scattering data in the angular range up to 179° and for nine α-particle energies from 22.1 to 28.2 MeV was performed in order to investigate whether the so-called nuclear glory effect is contained in the optical model. Six four-parameter potentials describing the elastic scattering were found with a depth of the real part ranging from 100 to 300 MeV. Only potentials with a real part deeper than 200 MeV can reproduce the backward scattering. The radius parameters corresponding to these deep potentials are rather small ($r_0$ = 1.1 fm). It was shown in an additional study that partial waves corresponding to the surface region of the target nucleus play an essential role in the backward scattering. (auth)

**19223** STUDY OF DEFORMATION IN LIGHT NUCLEI. I. APPLICATION TO THE GROUND STATE BAND OF $^{20}$Ne AND TO THE LOW-ENERGY SPECTRUM OF $^{19}$F. Benson, H. G.; Flowers, B. H. (Manchester Univ., Eng.). Nucl. Phys., A126: 305-31(1969).

The properties of the ground state band of $^{20}$Ne are shown to be well described by the set of wave functions projected from a single intrinsic state. Particular deformed states of nuclei around $^{16}$O may be constructed by breaking up the $^{16}$O core in such a manner as to produce two protons and two neutrons in the (2s,1d) shell. Following an observation by Christy and Fowler, the wave function for these four particles was described in terms of the ground state $^{20}$Ne band and deformed states were obtained by coupling 1p hole states on to the members of this band. The odd-parity levels of $^{19}$F were described by coupling $p_{\frac{1}{2}}$ and $p_{\frac{3}{2}}$ proton holes on to the ground state $^{20}$Ne band and it is shown that the measured E1 transitions in $^{19}$F provide evidence for states of this structure. It is also shown that the low-lying even-parity levels of $^{19}$F are well described in terms of a single K = $\frac{1}{2}^+$ band, and these states were compared directly with those obtained from a full intermediate coupling calculation. Overlaps of over 99% were obtained for the ground state ($\frac{1}{2}^+$) and the $\frac{5}{2}^+$ members of the band. The structure of the K = $\frac{1}{2}^+$ band was interpreted on the basis of the nucleus having permanent $P_4$ as well as $P_2$ (Nilsson) type distortions. Electromagnetic transitions in $^{19}$F are discussed in detail and the results for the odd-parity states are compared with those of a similar calculation by Harvey in the $SU_3$ scheme. A detailed study of the levels in $^{19}$F in the region of 4 to 5 MeV excitation was made and the extent to which core deformation is important in the even parity states is discussed on a semi-quantitative basis. The properties of the 3.91 MeV level (possibly a doublet) are crucial to the detailed interpretation of this nucleus. (auth)

**19224** ELASTIC SCATTERING OF ALPHA PARTICLES ON $^{39}$K AT $E_\alpha$ = 22.1 TO 28.2 MeV. Bobrowska, A.; Budzanowski, A.; Grotowski, K.; Jarczyk, L.; Micek, S.; Niewodniczanski, H.; Strzalkowski, A.; Wrobel, Z. (Inst. of Nuclear Physics, Krakow. Jagellonian Univ., Krakow). Nucl. Phys., A126: 361-8(1969).

Angular distributions for elastic α-particle scattering on $^{39}$K were measured over the angular range θ = 20 to 179° cm at $E_\alpha$ = 22.1, 23.1, 23.6, 24.0, 24.6, 25.5, 26.5, 27.4, and 28.2 MeV. A strong increase of the cross section was observed at the backward scattering angles with a well-developed oscillatory character. The experimental data were fitted with the semiclassical diffraction model at forward angles and the glory scattering model at backward angles. A difference of about 1 fm in radius parameters was found for the two models. (auth)

**19225** THERMAL-NEUTRON CAPTURE GAMMA RAYS FROM THE $^{27}$(n,α)$^{28}$Al REACTION. Hardell, R.; Idetjaern, S. O.; Ahlgren, H. (Chalmers Univ. of Tech., Goeteborg). Nucl. Phys., A126: 392-400(1969).

The energies and intensities of thermal-neutron capture gamma rays from $^{28}$Al were measured by means of a Ge(Li) pair spectrometer and anti-Compton spectrometer. An internal reactor target was used. The reaction Q-value, excitation energies and a decay scheme of $^{28}$Al were deduced. (auth)

**19226** COULOMB STRIPPING IN THE REACTION $^{89}$Y(d,p)$^{90}$Y AT 4 MeV BOMBARDING ENERGY. Yamaya, T.; Nakagome, Y.; Hiratate, Y.; Lee, S. M.; Iwasaki, S.; Tohei, T.; Morita, S. (Tohoku Univ., Sendai). Nucl. Phys., A126: 449-63 (1969).

The $^{89}$Y(d,p)$^{90}$Y reaction leading to the states of $^{90}$Y up to an excitation of 3.142 MeV was studied with bombarding energy below the Coulomb barrier. Excitation curves were measured over the deuteron energy range 3.2 to 4.2 MeV with solid-state detectors. Angular distributions were obtained at 4-MeV deuteron energy with a broad-range magnetic spectrograph and were compared with the DWBA and the Coulomb stripping theory. Spectroscopic factors were deduced. The validity of the Coulomb stripping theory is discussed for the proton groups leading to the observed higher excited levels. The angular distributions for the states of $E_x \geq$ 2.479 MeV are well reproduced by the Coulomb stripping analysis. The 0.780 MeV (2$^+$) level was observed with an intensity of 1.5% of that for the ground state doublet. (auth)

**19227** THE $^{42,44}$Ca(p,t)$^{40,42}$Ca REACTIONS AT 26.5 MeV. Smith, S. M.; Bernstein, A. M. (Massachusetts Inst. of Tech., Cambridge). Contract AT(30-1)-2098. Nucl. Phys., A125: 339-57(1969).

The $^{42}$Ca and $^{44}$Ca(p,t) reactions at 26.5 MeV were examined with a triton energy resolution of 110 keV. Differential cross sections were obtained for six levels in $^{40}$Ca and eleven levels in $^{42}$Ca below an excitation energy in both nuclei of approximately 5 MeV; they are compared with theoretical angular distributions calculated using the zero-range distorted-wave Born approxima-

tion (DWBA) in the two-nucleon transfer formalism of Glendenning. Woods–Saxon wave functions described the bound states of each of the individual transferred neutrons. The theoretical predictions for a given transition were found to be extremely sensitive to optical-model parameters, well parameters and shell-model configurations of the wave functions of the transferred neutrons. Therefore only qualitative information could be extracted from the data. In the $^{42}Ca(p,t)^{40}Ca$ reaction, the first excited $0^+$ state at 3.35 MeV was excited approximately 13% as strongly as the ground state. This is inconsistent with this state being a pure two-hole-two-particle configuration if pure shell-model ground state configurations are assumed. In the $^{44}Ca(p,t)$ reaction, the first excited $0^+$ state in $^{42}Ca$ at 1.84 MeV was excited only 2% as strongly as the ground state; this is consistent with a predominantly four-particle-two-proton-hole configuration for this state. The proton elastic differential cross sections for $^{42}Ca$ were measured to aid in the selection of proton optical-model parameters. (auth)

**19228** DECAY OF $^{62}Co$. Mo, J. N.; Ray, S.; Mark, S. K. (McGill Univ., Montreal). Nucl. Phys., A125: 440-8(1969).

Gamma rays following $\beta$ decay of $^{62}Co$ were studied using a 25-$cm^3$ Ge(Li) detector; Ge–NaI coincidence measurements were also performed. The previously reported spin 3 state is not populated by this decay. The 1.47-MeV gamma ray reported in previous work is not observed; additional gamma rays at 1163 keV and 2103 keV are discovered. A new decay scheme is proposed. (auth)

**19229** NOTE ON THE GAMMA RAY SPECTRUM FROM THE $^{47}Ca$ DECAY. Wood, R. E.; Palms, J. M.; Rao, P. Venugopala (Emory Univ., Atlanta). Nucl. Phys., A126: 300-4(1969).

Gamma rays of energy 41.06 ± 0.05 and 1878 ± 0.5 keV from the decay of $^{47}Ca$ were studied with high-resolution Ge(Li) spectrometers using singles and coincidence methods. (auth)

**19230** AN l-DEPENDENT ABSORPTION IN THE OPTICAL-MODEL DESCRIPTION OF $^{40}Ca(\alpha,\alpha_0)^{40}Ca$ SCATTERING. Bisson, A. E.; Davis, R. H., (Florida State Univ., Tallahassee). Phys. Rev. Lett., 22: 542-4(Mar. 17, 1969).

An l-dependent absorption was introduced in an optical-model analysis of $^{40}Ca(\alpha,\alpha_0)^{40}Ca$ energy-averaged angular-distribution data in the bombarding-energy range 5.5 to 17.5 MeV. Above 10.5 MeV, a marked improvement in the description results with $\chi^2$ values reduced to an average value of ~5. Below 10.5 MeV, the fits are not substantially improved over those obtained in a previous analysis. (auth)

**19231** STRUCTURE IN THE SILICON PHOTONEUTRON CROSS SECTION. Costa, S. (Univ., Turin. Istituto Nazionale di Fisica Nucleare, Turin); Ferrero, L.; Pasqualini, L.; Ferrero, F.; Manfredotti, C. Nuovo Cim., Lett., 1: 346-8(Feb. 21, 1969).

The photoneutron cross section of Si was measured for photon energies of 14 to 38 MeV using a thermalized neutron detector consisting of ten highly enriched $BF_3$ proportional counters embedded in a large cube of paraffin and arranged cylindrically around the photon beam passing through an axial hole containing the Si monocrystal. Six absorption lines were observed between 17.2 and 22 MeV; a reasonable fit of the experimental data was obtained with a superposition of Lorentz curves. Dipole strengths were calculated using the particle–hole model and the dynamic theory of the collective model. Important contributions to the cross section arising from the dipole strengths predicted theoretically between 25 and 29 MeV and at about 35 MeV were observed experimentally. (D.C.W.)

**19232** DIRECT CAPTURE OF THERMAL NEUTRONS BY NUCLEI WITH A ~ 50. Belousova, V. I.; Rudak, E. A.; Firsov, E. I. (Inst. of Physics, Minsk). Yadern. Fiz., 9: 100-1(Jan. 1969). (In Russian).

The cross section for direct capture of thermal neutrons into p levels was calculated for nuclei with A ~ 50. The neutron wave functions of the Saxon–Woods type were used in the calculations. The dependence of the cross section of the direct capture on the parameter characterizing the diffuse edge of the potential well and on the imaginary part of the optical potential was investigated. (auth)

**19233** ANGULAR-CORRELATION STUDIES OF THE REACTION $^{24}Mg(\alpha,p\gamma)^{27}Al$. Carter, K. W.; Elliott, R. V.; Kean, D. C.; Spear, R. H. (Australian National Univ., Canberra). Nucl. Phys., A126: 49-59(1969).

The 3.68-, 3.96-, 4.05-, and 4.58-MeV levels of $^{27}Al$ were studied via angular correlation measurements of the reaction $^{24}Mg(\alpha,p\gamma)^{27}Al$. The results are used in conjunction with previous information on lifetimes and branching ratios to impose limitations on possible spins, parities, and multipole mixing ratios. New information on the gamma-ray decay scheme of the 4.58-MeV level is presented. (auth)

**19234** E2 TRANSITION RATES FOR $^{20}Ne$. Ford, William F.; Braley, Richard C. (Lewis Research Center, Cleveland). Nucl. Phys., A126: 671-4(1969).

E2 transition rates in $^{20}Ne$ are calculated using projected Hartree–Fock wave functions. Some of the calculations are made with enlarged basis function spaces, or with states with Wood–Saxon radial dependence. Results are compared to upper limits predicted by SU(3). (auth)

**19235** ELASTIC SCATTERING OF 28-MeV PROTONS FROM Al, Si, Cu, Ag, AND Au. Dittman, Roger (Univ. of Southern California, Los Angeles. California State Coll., Fullerton); Sandhu, Harbhajan S.; Cole, Robert K.; Waddell, Charles N. Contract AT(04-3)-136. Nucl. Phys., A126: 592-608(1969). (USC-136-139).

The differential scattering cross sections of 28-MeV protons scattered from Al, Si, Cu, Ag, and Au were measured from 15 to 150° (cm). Analyses of these data using the diffuse-surface optical model of the nucleus are presented. (auth)

**19236** STRUCTURE OF $^{42}Ca$ AND $^{42}Sc$ INVESTIGATED BY TWO-NUCLEON TRANSFER REACTIONS. Barz, H. W. (Zentralinstitut fuer Kernforschung, Rossendorf, Ger.); Hehl, K.; Riedel, C.; Broglia, R. A. Nucl. Phys., A126: 577-91(1969).

The low-lying states of $^{42}Ca$ and $^{42}Sc$ were calculated in the coexistence model using effective matrix elements obtained from a Hamada–Johnston potential. The resulting wave functions are used to analyze the reactions $^{40}Ca(t,p)^{42}Ca$ and $^{40}Ca(^3He,p)^{42}Sc$. A detailed comparison between theory and experiment is presented. The influence of a spin-orbit coupling in the optical potential on angular distributions and proton polarization is discussed briefly. (auth)

**19237** DOUBLE CHARGE EXCHANGE OF $\pi^-$-MESONS AT SMALL ENERGIES. Batusov, Yu. A.; Bunyatov, S. A.; Sidorov, V. M.; Yarba, V. A. (Joint Inst. for Nuclear Research, Dubna, USSR). Yadern. Fiz., 9: 150-1(Jan. 1969). (In Russian).

Some events of double charge exchange of $\pi^-$-mesons on nuclei of emulsion were registered at the energy of 15 MeV. The cross section is $(4.6 \pm 3.4) \cdot 10^{-29}$ $cm^2$. The double charge exchange of slow $\pi^-$-meson was investigated at the capture by the $^{58}Ni$ nuclei. The probability of this reaction related to the total probability of the $\pi^-$-meson capture by Ni is found to be less than $3 \cdot 10^{-6}$. (auth)

**19238** HALF-LIFE OF $^{28}Al$. Wyttenbach, A.; Dulakas, H. (Eidgenoessisches Institut fuer Reaktorforschung, Wuerenlingen, Switzerland). J. Radioanal. Chem., 2: 287-90(Mar. 1969).

The correct value for the half-life of $^{28}Al$ is of some importance in view of the extended use that is made in activation analysis of this isotope, both in the determination of Al by the $^{27}Al(n,\gamma)^{28}Al$ reaction and of Si by the $^{28}Si(n,p)^{28}Al$ reaction. A redetermination of the half-life of $^{28}Al$ gave 2.24 ± 0.01 min; this value is in agreement with only one other determination, but differs considerably from the value of 2.31 min which is generally accepted as the half-life for $^{28}Al$. (auth)

**19239** THE $^{27}Al(p,\gamma)^{28}Si$ REACTION AT THE PROTON ENERGIES 1118, 1172, 1183, 1199, AND 1328 keV. Simons, L.; Forsblom, I.; Kiuru, A.; Raesaenen, J.; Viitasalo, M.; Fant, B.; Sola, P.; Oesterlund, K. (Univ. of Helsinki). Commentat. Phys.-Math., 34: No. 8, 47-66(1969).

The decay schemes for the resonances at $E_p$ = 1118, 1172, 1183, 1199, and 1328 keV were obtained. The resonance at $E_p$ = 1183 keV decays 5% to the first excited $0^+$ level in $^{28}Si$, which is observed excited for the first time in the $(p,\gamma)$ reaction. For the 1328-keV resonance level, the spin $J^\pi = 3^{(+)}$ was obtained and it is concluded that the 1183-keV resonance level has $2^+$ and that the 8.41-MeV $^{28}Si$ level has $3^+$. There is some indication of $J^\pi = 2^-$ for the 1172-keV resonance. (auth)

**19240** DWBA AND THE 3.12 MeV STATE IN $^{60}Ni$. Jolly, R. K. (Atomic Energy Research Establishment, Harwell, Eng); Goldberg, M. D.; Sengupta, A. K.; Darcey, W.; Chapman, R.; Hinds, S. Phys. Lett., 28B: 546-7(Feb. 3, 1969).

The apparent inconsistency and failure of DWBA analyses applied to (d,d') angular distribution data for the 3.12-MeV state of $^{60}Ni$, measured at $E_d$ = 11.5 MeV and 14.8 MeV, are explained by (t,p) measurements which suggest that the state is a $2^+$, $4^+$ doublet. (auth)

**19241** LOW-LYING SHELL-MODEL STATES IN $^{50}V$. Blasi, P. (Univ., Florence. INFN, Florence); Maurenzig, P. R.; Taccetti, N.; Ricci, R. A. Phys. Lett., 28B: 555-7(Feb. 3, 1969).

Transitions between low-lying levels of $^{50}V$ were studied with

the $^{50}Ti(p,n\gamma)^{50}V$ reaction. Multipolarities of transitions and spins of levels were deduced. (auth)

**19242** THE NEUTRON ENERGY SPECTRA FROM THE ($\mu^-$, $\nu$n) REACTION ON $^{32}S$ AND $^{40}Ca$. Evseyev, V.; Kozlowski, T.; Roganov, V.; Wojtkowska, J. (Joint Inst. for Nuclear Research, Dubna, USSR). Phys. Lett., 28B: 553-4(Feb. 3, 1969).

A line structure in the energy spectra of neutrons from $\mu^-$ capture in sulfur and calcium was observed. These results are the first direct confirmation of the resonance mechanism of muon capture. (auth)

**19243** SHELL MODEL DESCRIPTION OF STATES IN $^{38}K$. Dieperink, A. E. L.; Glaudemans, P. W. M. (Univ., Utrecht). Phys. Lett., 28B: 531-3(Feb. 3, 1969).

Electromagnetic properties of levels in $^{38}K$ are calculated with the Tabakin interaction and the modified surface delta interaction. These properties appear to depend sensitively on the interaction. It is found that the Tabakin interaction much better reproduces experimentally observed transition rates than the modified surface delta interaction. (auth)

## Nuclear Properties and Reactions, A ≥ 90

*Refer also to abstracts 18821, 19026, 19129, 19158, 19174, 19183, 19199, 19202–19204, 19206, 19209, 19217, 19219, 19226, 19235, 19319, 19327, 19367, and 19383.*

**19244** (AE-344) A STUDY OF THE RESONANCE INTERACTION EFFECT BETWEEN $^{238}U$ AND $^{239}Pu$ IN THE LOWER ENERGY REGION. Haeggblom, H. (Aktiebolaget Atomenergi, Stockholm (Sweden)). Dec. 1968. 48p. Dep.

An investigation was made of the statistical frequency function for the distances between the $^{238}U$ and the $^{239}Pu$ resonances in the region 4 to 244 eV. It was concluded that the frequency function is probably constant but that the distances diverge appreciably from a constant function in the actual case, and that the divergence is such that the interaction effect on the resonance integral is smaller than would be expected from statistical considerations. This was also confirmed by calculations on the interaction effect. These were performed using three different methods, namely: considering the actual positions and widths of the resonances; assuming a constant frequency function for the resonance spacing and applying a theory developed by J. L. Rowlands and E. A. Fischer; and applying a simplified, approximate method for calculations based on the statistical theory. The calculations were made for two temperatures and two values of the plutonium enrichment. It was shown that the average cross sections are considerably larger than the statistical calculations indicated. (auth) (Sweden)

**19245** (CEA-R-3571) CONTRIBUTION TO THE STUDY OF DEFORMED HEAVY NUCLEI BY MEANS OF NUCLEAR REACTIONS. Gastebois, Jean (Commissariat a l'Energie Atomique, Saclay (France). Centre d'Etudes Nucleaires). 1968. 98p. (In French). Dep.

Thesis. Submitted to Univ. of Paris, Orsay, France.

The experimental results obtained in a study of the (d,p) reactions at $E_d$ = 12 MeV on the three even–even deformed nuclei $^{170}Yb$, $^{172}Yb$ and $^{174}Yb$ were analyzed in terms of DWBA calculations. The spectroscopic information on the odd final nuclei was compared with the predictions of the collective model and of the Nilsson model. The effect of various parameters used in the DWBA analysis (form factors, optical wave functions) was carefully studied. The observed differences between the three final nuclei are qualitatively reproduced in the experimental study of resonances seen in excitation functions of elastically and inelastically scattered protons on the same target nuclei and corresponding to analogue states in the three nuclei $^{171}Lu$, $^{173}Lu$, and $^{175}Lu$. (auth)

**19246** (DESY-68/57) ($\gamma$,n) REACTIONS IN THE ENERGY RANGE FROM 1.0 TO 5.5 GeV. de Carvalho, H. G.; di Napoli, V.; Margadonna, D.; Salvetti, F.; Tesch, K. (Deutsches Elektronen-Synchrotron, Hamburg (West Germany)). Nov. 1968. 16p. Dep.

The ($\gamma$,n) cross sections per equivalent quantum of $^{12}C$, $^{103}Rh$, $^{127}I$, $^{197}Au$, and $^{238}U$ were measured with a bremsstrahlung beam of maximum energies in the range from 1 up to 5.5 GeV. Within the experimental errors of the activation method, no contribution of photons above 1 GeV was found. This result disagrees with some previous measurements made at energies below 1 GeV but agrees with the predicted values obtained from simple theoretical estimates. (auth)

**19247** (GAMD-8067) EVALUATION OF $^{233}U$ CROSS SECTIONS WITH NUMERICAL ANALYSIS OF INTEGRAL EXPERIMENTS. Traylor, R. C. (Gulf General Atomic, Inc., San Diego, Calif.). Sept. 26, 1968. Contract AT(04-3)-167. 26p. Dep. CFSTI.

As an integral numerical evaluation of uranium-233 neutron cross sections, an analysis of three homogeneous water-moderated critical assemblies was undertaken. The analysis of these soft spectrum critical assemblies supplements the reactivity coefficient experiments with uranium-233 in the harder spectrum HTGR Critical Assembly. The three spherical assemblies are characterized by hydrogen-to-fissile atom ratios of 1521, 405, and 381; the first and last were bare while the H/U-233 = 405 assembly was reflected. To help understand the results of U-233 assembly analysis, a uranium-235 assembly with spectrum similar to the harder U-233 assemblies was also analyzed (H/U-235 = 525) using the latest evaluation of the better known cross sections for U-235. Multigroup one-dimensional diffusion theory and transport theory computer codes were used to calculate the effective multiplication constant ($k_{eff}$) of each assembly. (auth)

**19248** (IA-1180) POLARIZATION MEASUREMENTS OF RESONANTLY SCATTERED CAPTURE GAMMA RAYS. Moreh, R.; Amit (Friedman), M.; Rajewski, J. (Israel Atomic Energy Commission, [Tel Aviv]). May 1968. 24p. Dep.

The parities of levels excited by resonance scattering of $\gamma$ rays from neutron capture in iron were measured with a Compton polarimeter. The spins and parities of resonance levels in four isotopes were thus found to be $^{208}Pb$ (7.279 MeV, $1^-$), $^{112}Cd$ (7.632 MeV, $1^+$), $^{141}Pr$ (7.632 MeV, $5/2^-$), and $^{62}Ni$ (7.646 MeV, $1^+$), which correspond to E1, M1, E1, and M1 radiation, respectively. The results are discussed in the light of Axel's suggestion regarding the association of these resonances with the tail of the electric giant dipole resonance. (auth)

**19249** (INR-P-952) LITHIUM AND BERYLLIUM NUCLEI EMITTED DURING THE THERMAL NEUTRON FISSION OF $^{235}U$. Blocki, J.; Chwaszczewska, J.; Dakowski, M.; Krogulski, T.; Piasecki, E.; Sowinski, M.; Stegner, A.; Tys, J. (Institute of Nuclear Research, Warsaw (Poland)). 1968. 13p. Dep.

The energy spectra and relative yields of lithium and beryllium nuclei emitted during the thermal neutron fission of $^{235}U$ were investigated using a two-counter telescope with a proportional counter as the $\Delta E$ detector. An attempt was made to compare the experimental results with model calculations. (auth)

**19250** (JINR-P2-4183) ENERGY DEPENDENCE OF THE NUCLEAR CROSS SECTIONS FOR NUCLEONS AT ENERGY ABOVE 50 MeV. Barashenkov, V. S.; Gudima, K. K.; Toneev, V. D. (Joint Inst. for Nuclear Research, Dubna (USSR). Lab. of Theoretical Physics). 1968. 32p. (In Russian). Dep.

The curves of the energy dependence of the integral cross sections $\sigma_t$, $\sigma_{in}$, $\sigma_{el}$ are given for the interactions of protons with Be, C, Al, Ti, Fe, Cu, Cd, Pb, and U nuclei. (auth)

**19251** (JINR-P4-4259) EFFECT OF THE HEXADECAPOLE DEFORMATION ON THE PROPERTIES OF ONE-QUASI-PARTICLE STATES OF THE RARE-EARTH NUCLEI. Gareev, F. A.; Ivanova, S. P.; Shirikova, N. Yu. (Joint Inst. for Nuclear Research, Dubna (USSR)). 1969. 22p. (In Russian). Dep.

The effect of the $\beta_{40}$ deformation on the properties of one-quasiparticle states of the rare-earth nuclei is investigated. It is shown that a number of characteristics, such as the local level density, the decoupling parameters, and the interval of the level quasi-intersection, are changed, depending on the hexadecapole deformation value. (auth)

**19252** (KURRI-TR-8, pp 4-23) MOESSBAUER EFFECT IN NUCLEAR PHYSICS. Shikazono, Naomoto (Japan Atomic Energy Research Inst., Tokyo). (In Japanese).

The application of the Moessbauer effect to nuclear physics is reviewed, including the author's original studies. The effect as applied to measurement of natural width, the mixing ratio, isomeric shift, and hyperfine structure is discussed. Measurement of the natural width refers to the application of the Doppler effect to determine the natural width of $\gamma$ radiation, directing a moving $\gamma$-ray source toward a thin absorber. Coincidence counting of $\gamma$ cascades makes it possible to determine the sublevel population of intermediate states, from which the mixing ratio of the forward $\gamma$ radiation may be derived. The slight differences in the radii of isomeric nuclei are indicated by differences in the energy levels. Exposure of these nuclei to $\gamma$ radiation results in differences of the position of the resonant energy, producing the isomer shift. The method is especially useful for the study of large nuclei. The hyperfine structure of excited states yields directly the magnetic and quadrupole moments. The method is useful for evaluating the accuracy of nuclear models. The atoms, the nuclear prop-

erties of which have been studied by the Moessbauer effect include $^{57}$Fe, $^{61}$Ni, $^{119}$Sn, $^{125}$Te, $^{127}$I, $^{129}$I, $^{129}$Xe, $^{151}$Eu, $^{153}$Eu, $^{160}$Dy, $^{161}$Dy, $^{166}$Er, $^{169}$Tm, and $^{197}$Au. (TTT)

**19253** (ORO–2972-80) RESEARCH IN NUCLEAR PHYSICS. Progress Report No. 7. (Texas Univ., Austin. Center for Nuclear Studies). Dec. 1968. Contract AT(40-1)-2972. 54p. Dep. CFSTI.

An intensive study of isobaric analog resonances in various isotopes of Kr, Te, Xe, Cd, Ag, Zr, Mo, and Sc has produced a wealth of information with respect to level structure, spins, parities, and spectroscopic factors of the states observed. Studies of direct interaction and fluctuations in the reaction $^{31}$P(d,$\alpha$)$^{29}$Si were performed and were compared to the predictions of the Ericson fluctuation theory. Direct reaction investigations in isotopes of Be, B, C, N, P, Cr, Zr, Mo, Y and Xe yielded substantial results on charge exchange threshold effects, direct nucleon pickup, spectroscopic factors, and nuclear structure. A broad theoretical investigation of the phenomena observed was conducted. A comparison of the experimental data and results obtained from the various programs to theoretical prediction using the shell model approach, coupled channel DWBA theory and various optical model parameters was relatively successful. New theoretical approaches to provide a more detailed description of isobaric analog resonances were developed. Twenty-one computer programs were developed for the analysis of data and the theoretical prediction of nuclear structure and spectroscopic factors. Instrumentation as well as new research facilities and techniques was developed. (auth)

**19254** (ORO–3624-7) PROGRESS REPORT [ON PHYSICS]. Seagondollar, L. W. (North Carolina State Univ., Raleigh). [1968]. Contract AT(40-1)-3624. 73p. Dep. CFSTI.

Investigations of neutron reactions and scattering, neutron resonance parameters, charged-particle reactions and scattering, analog resonances, direct reactions, optical-model analysis, nuclear energy levels, and nuclear decay are summarized. Developments in semiconductor detectors and spectrometers and in accelerator facilities are also outlined. (D.C.W.)

**19255** (OULNS–69-1) EXCITATION FUNCTIONS FOR THE (d,p) REACTIONS ON $^{96}$Ru, $^{102}$Ru, AND $^{104}$Ru. Mito, A.; Komura, K.; Mitsugashira, T.; Otozai, K. (Osaka Univ. (Japan). Lab. of Nuclear Studies). [1968]. 22p. Dep.

Excitation functions for the (d,p) reactions on $^{96}$Ru, $^{102}$Ru, and $^{104}$Ru were measured with the activation method up to 14.0-MeV deuteron energy. The results were explained with the modified Peaslee theory by using different values of the total absorption parameter. It was found on the even–even target nuclei that the values of $\rho$ for the (d,p) reactions grow large as their isotopic numbers N-Z increases. (auth)

**19256** (RT/FI–(68)37) SLOW NEUTRON RESONANCES IN PALLADIUM ISOTOPES. Coceva, C.; Corvi, F.; Giacobbe, P.; Stefanon, M. (Comitato Nazionale per l'Energia Nucleare, Rome (Italy)). 1968. 7p. (CONF-650706–27). Dep.

From International Conference on the Study of Nuclear Structure with Neutrons, Antwerp.

Transmission measurements were made on small samples of the separated isotopes $^{105}$Pd and $^{108}$Pd using a fast chopper. Resonance parameters were obtained for resonances up to 90 eV by shape analysis of the transmission data. The results for $^{105}$Pd were used to calculate the s-wave strength function for the resonances of each spin state; no difference was observed. The radiative widths for $^{105}$Pd show differences that may be interpreted as a dependence of $\Gamma_\gamma$ on the spin of the level; no definite conclusion could be reached on this point. (D.C.W.)

**19257** (SC-M–68-827) A TABULATION OF FISSION NUCLIDES VS SELECTED TIME PERIODS AFTER FISSION, LISTED IN ORDER OF DECREASING GAMMA RAY ENERGY INTENSITY. Lemmons, John L.; Matthews, Paul O. (Sandia Labs., Albuquerque, N. Mex.). Dec. 1968. 143p. Dep. CFSTI.

Fission product nuclides are tabulated for selected time periods after fission. For each time period the nuclides present are listed in order of decreasing gamma-ray energy intensity. (auth)

**19258** A STUDY OF GAMMA-RAY SPECTRA OF THERMAL NEUTRON CAPTURE IN $^{143}$Nd AND $^{145}$Nd, INCLUDING DIRECTIONAL ANISOTROPY AND LINEAR POLARIZATION MEASUREMENTS OF SUCH GAMMA RAYS FROM ALIGNED $^{143}$Nd NUCLEI. Reddingius, E. R.; Potters, J. F. M.; Postma, H. (Kamerlingh Onnes Laboratorium, Leiden. Reactor Centrum Nederland, Petten). Physica, 38: 48-66(Mar. 1968).

The $\gamma$-ray spectra following thermal neutron capture in $^{143}$Nd and $^{145}$Nd were investigated with a 5-cc Ge(Li) detector. Samples enriched in $^{143}$Nd and $^{145}$Nd were used. Energies and intensities of several transitions are given. The anisotropy of the directional distribution of neutron-capture $\gamma$ rays from aligned $^{143}$Nd nuclei was measured. The degree of linear polarization of the 814- and 864-keV transitions in $^{144}$Nd were determined by using a Compton polarimeter. The E2 transitions of 616 and 696 keV were used for calibrating the efficiency of the polarimeter. The spins of the levels at 1560, 2292, 2377 and 2862 keV were determined from the anisotropy measurements. They are 2, 4, 2, and 2, respectively. The spins of the levels at 3027 and 3137 keV are very likely 4 and 3, respectively. The anisotropy and linear polarization measurements indicate that the 814 keV transition has an E1 character, while the 864 keV $\gamma$ radiation is mainly an M1 transition with 18–38% admixture of E2. A compilation of E2–M1 mixing ratios for $2^+ \rightarrow 2^+$ transitions for nuclei with $18 \leq A \leq 212$ is given. (auth)

**19259** COLLECTIVE INTERACTION OF NUCLEI WITH RESONANCE GAMMA-RADIATION. Voitovetskii, V. K.; Korsunskii, I. L.; Pazhin, Yu. F. Dokl. Akad. Nauk SSSR, 183: 1045-7(Dec. 11, 1968). (In Russian).

The dynamic theory of resonance scattering of gamma radiation in ideal crystals as compared to scattering under ordinary conditions predicts not only a change in resonance parameters but also a suppression of inelastic scattering due to collective interaction of the nuclei, when the wavelength of the radiation is comparable with the interatomic distance. Experiments were run on the diffraction of resonance gamma radiation in single crystals of tin ($^{119}$Sn isotope has a 23.8-keV transition). The scattered and transmitted gamma radiation was detected by a scintillation counter. A suppression of inelastic scattering was found. The resonance absorption in the crystal was 38.5%, when the Bragg condition of reflection was not fulfilled, and only 10% when the Bragg condition was fulfilled. These data are direct proof for the suppression of inelastic scattering predicted by theory. (TTT)

**19260** DECAY SCHEME OF $^{144}$Pr. El Bedewi, F. A.; Miligy, Z.; Eissa, N. A.; Morsy, M. (Ein Shams Univ., Cairo). Acta Phys. Acad. Sci. Hung., 25: 197-203(1968).

The decay of the 17.5 min $^{144}$Pr was investigated with a scintillation spectrometer. The energies of the $\gamma$ transitions in the daughter nucleus $^{144}$Nd were found to be 2.18, 1.49 and 0.70 MeV in agreement with the measurements of other investigators. The ambiguities concerning the previously reported 2.8, 1.67 and 1.16 MeV $\gamma$ transitions are removed. A decay scheme is proposed. (auth)

**19261** DECAY SCHEME OF $^{111}$Pd AND $^{111m}$Pd. El Bedewi, F. A.; Miligy, Z.; Eissa, N. A.; Morsy, M. (Ein Shams Univ., Cairo). Acta Phys. Acad. Sci. Hung., 25: 205-14(1968).

The $\gamma$ spectra accompanying the decay of the 22-min $^{111}$Pd and the 5.5 h $^{111m}$Pd, were studied with a scintillation $\gamma$ ray spectrometer. Seven new $\gamma$ transitions were found to be associated with the decay of $^{111}$Pd. The energies of these $\gamma$ rays are 220, 300, 350, 500, 770, and 1150 keV. A scheme representing the decay of $^{111}$Pd and $^{111m}$Pd is proposed. (auth)

**19262** LEVELS POPULATED IN $^{193}$Ir FROM THE BETA DECAY OF $^{193}$Os. Price, R. H.; Johns, M. W.; Ahmed, N. M.; Habib, E. E. (McMaster Univ., Hamilton, Ont.). Can. J. Phys., 47: 727-46(Apr. 1, 1969).

The beta and gamma transitions involved in the decay of $^{193}$Os were studied using Ge(Li) and NaI(Tl) detectors and magnetic spectrometers, singly and in coincidence. Fifty-four gamma transitions were observed, and all but one was classified on the basis of energy fit and $\beta$-$\gamma$ and $\gamma$-$\gamma$ coincidence measurements. The internal conversion coefficients of 25 of the stronger transitions were determined with a magnetic spectrometer operating at a resolution of ~0.1% in momentum, and multipole mixing ratios determined. The energies and spins of levels in $^{193}$Ir were determined as follows: 0 ($3/2^+$), 73.006 ($1/2^+$), 138.887 ($5/2^+$), 142.125 ($^+$), 180.00 ($3/2^+$), 357.7 ($1/2^+$), 361.79 ($5/2^+$), 440.95 ($^+$), 460.46 ($3/2^+$), 557.29 ($1/2^+$), 559.22 ($5/2^+$), 660.09 ($^+$), 667.13, 695.06 ($5/2^+$), 712.08 ($3/2^+$), 778.50, 784.13, 848.94, 874.45, 891.57. (auth) (Canada)

**19263** CROSS SECTIONS OF SOME REACTIONS OF HAFNIUM ISOTOPES WITH 14.5-MeV NEUTRONS. Hillman, M.; Shikata, E. (Brookhaven National Lab., Upton, N. Y.). J. Inorg. Nucl. Chem., 31: 909-13(Apr. 1969).

Hafnium oxide was irradiated with 14.5-MeV neutrons, and the resulting activities were identified by $\gamma$-ray spectrometry. The cross sections for the reactions $^{180}$Hf(n,n')$^{180m}$Hf, $^{176}$Hf(n,2n)$^{175}$Hf, $^{174}$Hf(n,2n)$^{173}$Hf, and $^{180}$Hf(n,$\alpha$)$^{177}$Yb, were determined to be 12.4 ± 0.5 mb, 2000 ± 100 mb, 860 ± 60 mb, and 2.2 ± 0.2 mb, respectively. (auth) (UK)

**19264** CROSS SECTIONS FOR THE FORMATION OF Sb AND Sc ISOTOPES BY IRRADIATION OF Y, La, Ta, AND Au WITH 18.2-GeV PROTONS. Hageboe, E.; Ravn, H. (CERN, Geneva). J. Inorg. Nucl. Chem., 31: 897-907(Apr. 1969).

It was found that the shapes of the yield-distribution curves for both Sb and Sc isotopes varied with the target element. If the previously known yield-distributions with uranium as targets are decomposed into a "spallation" part and a fission part, the former will in both cases be about equal to the distribution with gold or tantalum as the target, while in shape the fission part closely resembles the distributions obtained when uranium is irradiated with 570 to 590-MeV protons. From the variation in shape of the distribution curves with target this decomposition procedure seems less justified for the scandium isotopes than for antimony isotopes. The high spin to low spin isomeric yield ratios of the $^{44}$Sc isomers were also determined, and show a very definite increase with mass difference between target and product. (auth) (UK)

**19265** STUDY OF THE DECAY SCHEME FOR $^{122}$I. Lagrange, Jean-Marie (Institut de Physique Nucleaire, Orsay, France). Compt. Rend., Ser. A, B, 267: 1447-50(Dec. 23, 1968). (In French).

The study of $\gamma$ radiation arising from the decay of $^{122}$I permits a decay scheme to be proposed for this isotope and the levels obtained to be compared with those found from nuclear reactions. (tr-auth)

**19266** ENERGY DEPENDENCE OF SPIN CUTOFF PARAMETER ($\sigma$) IN RHODIUM AND INDIUM. Chaubey, A. K.; Sehgal, M. L. (Aligarh Muslim Univ., India). Proc. Nucl. Phys. Solid State Phys. Symp., 1968, Madras, 283-6(1968).

Isomeric cross section ratios were calculated for neutron capture by $^{115}$In and $^{103}$Rh at 0.025 eV to 1.7 MeV. Calculations were performed for several different values of the level density parameter $\sigma$ and compared with experimental values in order to study the energy dependence of $\sigma$. It was determined that $\sigma$ has no energy dependence. (J.W.R.)

**19267** STUDY OF WIDTH-FLUCTUATION EFFECTS IN (n,n') REACTION DIFFERENTIAL CROSS SECTIONS. Sharma, H. C.; Nath, N. (Banaras Hindu Univ., India). Proc. Nucl. Phys. Solid State Phys. Symp., 1968, Madras, 291-5(1968).

From Nuclear Physics and Solid State Physics Symposium, Madras, India. See CONF-680212.

Calculations were performed to test for width-fluctuation effects in differential cross sections for neutron inelastic scattering. The results for neutron inelastic scattering by $^{206}$Pb show that width-fluctuation effects play a significant role, especially for low-lying states. (J.W.R.)

**19268** RADIATIVE CAPTURE CROSS SECTIONS OF 25-keV NEUTRONS. Tirumala Rao, B. V.; Rama Rao, J.; Kondaiah, E. (Andhra Univ., Waltair, India). Proc. Nucl. Phys. Solid State Phys. Symp., 1968, Madras, 296-7(1968).

From Nuclear Physics and Solid State Physics Symposium, Madras, India. See CONF-680212.

Cross sections were determined for $^{115}$In(n,$\gamma$)$^{116m}$In and $^{130}$Te-(n,$\gamma$)$^{131g}$Te reactions at 25 keV using a 100-channel analyzer to measure the induced activity continuously. (J.W.R.)

**19269** CORRELATION BETWEEN THE NUMBER OF NEUTRONS EMITTED, THE SCISSION POINT CONFIGURATION, AND THE TOTAL KINETIC ENERGY IN FISSION. Mukherji, S.; Mehta, G. K. (Indian Inst. of Tech., Kanpur). Proc. Nucl. Phys. Solid State Phys. Symp., 1968, Madras, 302-4(1968).

From Nuclear Physics and Solid State Physics Symposium, Madras, India. See CONF-680212.

Calculations were performed to determine the correlation between the average number of neutrons emitted and the surface separation distance in the thermal neutron fission of $^{239}$Pu, $^{233}$U, and $^{235}$U. A striking correspondence was found for the case of $^{235}$U. (J.W.R.)

**19270** PROMPT GAMMA-RAY EMISSION IN THE SPONTANEOUS TERNARY FISSION OF $^{252}$Cf. Ajitanand, N. N. (Bhabha Atomic Research Centre, Trombay, India). Proc. Nucl. Phys. Solid State Phys. Symp., 1968, Madras, 305-7(1968).

From Nuclear Physics and Solid State Physics Symposium, Madras, India. See CONF-680212.

Gamma yields were measured for the spontaneous binary and ternary fission of $^{252}$Cf using a NaI(Tl) detector. The pulse-height distributions indicate that the largest difference is in the energy range below 300 keV. (J.W.R.)

**19271** NUCLEAR CHARGE DISTRIBUTION IN THERMAL-NEUTRON INDUCED FISSION OF $^{235}$U. Mukherji, Shankar (Indian Inst. of Tech., Kanpur). Proc. Nucl. Phys. Solid State Phys. Symp., 1968, Madras, 308-10(1968).

From Nuclear Physics and Solid State Physics Symposium, Madras, India. See CONF-680212.

It is shown that there is a simpler and more direct method of calculating the most probable charge associated with a given fission fragment than the equal charge displacement method if the attention is focused on the prompt fission fragments rather than the fission products. The method was used to determine the most probable charge for A = 130 to 150 fragments in the thermal neutron fission of $^{235}$U. (J.W.R.)

**19272** EMISSION OF K X-RAYS IN THE THERMAL FISSION OF $^{235}$U. Zaghloul, R.; Kapoor, S. S.; Ramamurthy, V. S. (Bhabha Atomic Research Centre, Trombay, India). Proc. Nucl. Phys. Solid State Phys. Symp., 1968, Madras, 311-13(1968).

From Nuclear Physics and Solid State Physics Symposium, Madras, India. See CONF-680212.

The K x-ray yield was measured as a function of the fragment mass in the thermal neutron fission of $^{235}$U. The data show that fragments with closed nuclear shells have a minimum yield while between shells the yield increases. (J.W.R.)

**19273** ENERGY-ANGLE CORRELATION OF LONG-RANGE ALPHA PARTICLES EMITTED IN THERMAL NEUTRON FISSION OF $^{235}$U. Nadkarni, D. M.; Rama Rao, P. N. (Bhabha Atomic Research Centre, Trombay, India). Proc. Nucl. Phys. Solid State Phys. Symp., 1968, Madras, 314-17(1968).

From Nuclear Physics and Solid State Physics Symposium, Madras, India. See CONF-680212.

The energy spectrum of long-range alpha particles emitted at 0 and 90° with respect to the direction of fragment separation in the thermal neutron fission of $^{235}$U was measured in order to check the effect of variations in the Coulomb field on alpha energies. (J.W.R.)

**19274** KINETIC ENERGY RELEASE IN REACTOR NEUTRON-INDUCED FISSION OF $^{232}$Th. Prakash, Satya; Manohar, S. B.; Rao, C. L.; Ramaniah, M. V. (Bhabha Atomic Research Centre, Trombay, India). Proc. Nucl. Phys. Solid State Phys. Symp., 1968, Madras, 318-21(1968).

From Nuclear Physics and Solid State Physics Symposium, Madras, India. See CONF-680212.

The range of fission fragments from the reactor-induced fission of $^{232}$Th was measured using radiochemical techniques. Several range-energy relationships were used to calculate the kinetic energy distribution. The kinetic energy deficit was found to be the same for all the calculations. In order to compare the kinetic energy deficit in the fission of $^{232}$Th with other systems, the correlation between the kinetic energy difference and the deformation of symmetric fission fragments was studied. (J.W.R.)

**19275** THE g-FACTOR OF THE 321-keV STATE IN $^{125}$Te. Tandon, P. N.; Devare, S. H.; Devare, H. G. (Tata Inst. of Fundamental Research, Bombay). Proc. Nucl. Phys. Solid State Phys. Symp., 1968, Madras, 322-4(1968).

From Nuclear Physics and Solid State Physics Symposium, Madras, India. See CONF-680212.

The g-factor for the 321-keV state of $^{125}$Te was measured using the method of perturbed angular correlations. (J.W.R.)

**19276** PARTICLE PARAMETERS IN THE INTERNAL CONVERSION OF E2 TRANSITIONS IN $^{152}$Sm. Agarwal, Y. K.; Baba, C. V. K.; Mukhopadhyay, Nimai C. (Tata Inst. of Fundamental Research, Bombay). Proc. Nucl. Phys. Solid State Phys. Symp., 1968, Madras, 326-7(1968).

From Nuclear Physics and Solid State Physics Symposium, Madras, India. See CONF-680212.

Measurements were made for $\gamma-\gamma$ and $\gamma-e$ angular correlations in the 122-keV E2 transition in $^{152}$Sm using a single gap spectrometer in the electron channel. Particle parameters for the internal conversion in the transition were determined and compared with other measurements and theoretical values. (J.W.R.)

**19277** EVIDENCE FOR DEFORMATION IN THE NEAR CLOSED SHELL NUCLEI. Sharma, R. P.; Pandharipande, V. R.; Prasad, K. G. (Tata Inst. of Fundamental Research, Bombay). Proc. Nucl. Phys. Solid State Phys. Symp., 1968, Madras, 328-30(1968).

From Nuclear Physics and Solid State Physics Symposium, Madras, India. See CONF-680212.

Recent work on the low-lying states of $^{115}$In and $^{117}$In gave evidence for deformed states in these nuclei. In order to get further information about these states the g-factor for the 660 keV state in $^{117}$In was measured using the differential-delay constant-angle method. The value obtained agrees with a theoretical value calculated on the basis of the Nilsson model for this level in a k = $\frac{1}{2}^+$

rotational band. Higher members of this band were taken from other data. An attempt was made to reproduce the levels by a rotational-model calculation. The agreement was good which supports the hypothesis of deformation in near closed-shell nuclei. (J.W.R.)

**19278** LOW-LYING LEVELS IN $^{111}$Ag. Prasad, K. G.; Sharma, R. P. (Tata Inst. of Fundamental Research, Bombay). Proc. Nucl. Phys. Solid State Phys. Symp., 1968, Madras, 331-3 (1968).

From Nuclear Physics and Solid State Physics Symposium, Madras, India. See CONF-680212.

Low-lying levels in $^{111}$Ag resulting from $\beta$ decay of $^{111}$Pd were studied using Ge(Li) detectors in order to check for the possible existence of deformed states. The K-conversion coefficient for the 80-keV transition was determined and an upper limit of 1 ns was established for the 147 keV level. (J.W.R.)

**19279** DECAY OF $^{180g,m}$Lu. Basu, D; Gujrathi, S. C. (Saha Inst. of Nuclear Physics, Calcutta). Proc. Nucl. Phys. Solid State Phys. Symp., 1968, Madras, 334-7(1968).

A scintillation spectrometer was used to study the $\beta$ and $\gamma$ spectra from $^{180}$Lu. A $\beta$ activity of $T_{\frac{1}{2}}$ = 7.5 min was found in addition to the previously recorded 2.5 min activity. (J.W.R.)

**19280** DECAY OF THE 18.8-min $^{126m}$Sb. Gujrathi, S. C.; Murthy, K. S. N.; Pathak, B. P.; Mukherjee, S. K. (Saha Inst. of Nuclear Physics, Calcutta). Proc. Nucl. Phys. Solid State Phys. Symp., 1968, Madras, 338-42(1968).

Scintillation spectrometers were used to measure $\beta$-$\gamma$ and $\gamma$-$\gamma$ coincidence spectra from $^{126m}$Sb. A half-life of 19.0 ± 0.5 min was assigned to the isomer. A level scheme for $^{126}$Te was determined from the measurements. (J.W.R.)

**19281** DECAY OF $^{186}$Ta. Gujrathi, S. C.; Pathak, B. P.; Murthy, K. S. N.; Mukherjee, S. K. (Saha Inst. of Nuclear Physics, Calcutta). Proc. Nucl. Phys. Solid State Phys. Symp., 1968, Madras, 343-7(1968).

From Nuclear Physics and Solid State Physics Symposium, Madras, India. See CONF-680212.

The $\beta$ decay of $^{186}$Ta was studied in order to obtain spectroscopic information on the excited states of $^{186}$W. Scintillation detectors were used to measure $\beta$ and $\gamma$ singles and coincidence spectra. Several new levels are proposed as a result of the measurements. (J.W.R.)

**19282** THE STRUCTURE OF THE 77-keV STATE IN $^{197}$Au. Rama Rao, M. T.; Ramamurthy, V. V.; Lakshminarayana, V. (Andhra Univ., Waltair, India). Proc. Nucl. Phys. Solid State Phys. Symp., 1968, Madras, 348-50(1968).

From Nuclear Physics and Solid State Physics Symposium, Madras, India. See CONF-680212.

The lifetime and transition probabilities of the 77-keV state in $^{197}$Au were determined by observing the k-conversion electrons feeding the state and the L-conversion electrons depopulating the state. The M1 and E2 transition probabilities were compared with estimates from the wavefunctions of Kisslinger and Sorenson. (J.W.R.)

**19283** THE DECAY OF $^{144}$Ce. Mangal, P. C.; Trehan, P. N. (Panjab Univ., Chandigarh, India). Proc. Nucl. Phys. Solid State Phys. Symp., 1968, Madras, 351-5(1968).

From Nuclear Physics and Solid State Physics Symposium, Madras, India. See CONF-680212.

A high-efficiency sum-peak coincidence spectrometer was employed in $3\pi$ geometry to study the decay of $^{144}$Ce to $^{144}$Pr and further to $^{144}$Nd. Energy levels along with spin-parity assignments were determined for $^{144}$Pr and $^{144}$Nd. (J.W.R.)

**19284** DECAY OF $^{94}$Y. Gujrathi, S. C.; Singh, H.; Mukherjee, S. K. (Saha Inst. of Nuclear Physics, Calcutta). Proc. Nucl. Phys. Solid State Phys. Symp., 1968, Madras, 356-60(1968).

From Nuclear Physics and Solid State Physics Symposium, Madras, India. See CONF-680212.

Beta and $\gamma$ singles as well as $\beta-\gamma$ and $\gamma-\gamma$ coincidence spectra were measured for $^{94}$Y. Log ft values were determined for the $\beta$ groups. A decay scheme for $^{94}$Y is proposed. (J.W.R.)

**19285** GAMMA-GAMMA COINCIDENCE AND ANGULAR CORRELATION STUDIES IN $^{181}$Ta FROM THE DECAY OF $^{181}$Hf. Singh, B. P.; Dahiya, H. S.; Pande, U. S. (Univ. of Roorkee, India). Proc. Nucl. Phys. Solid State Phys. Symp., 1968, Madras, 363-6(1968).

From Nuclear Physics and Solid State Physics Symposium, Madras, India. See CONF-680212.

Gamma-gamma coincidence spectra were measured for the 133, 346, and 482 $\gamma$ rays of $^{181}$Ta from the decay of $^{181}$Hf. Angular correlations were measured for the 133-482 and 346-476 keV cascades. The data indicate a level at 958 keV with a spin of $\frac{3}{2}$. (J.W.R.)

**19286** SPECTRA OF EVEN ISOTOPES OF CADMIUM AND TELLURIUM. Pandharipade, V. R. (Tata Inst. of Fundamental Research, Bombay). Proc. Nucl. Phys. Solid State Phys. Symp., 1968, Madras, 264-6(1968).

From Nuclear Physics and Solid State Physics Symposium, Madras, India. See CONF-680212.

The spectra for even isotopes of Cd and Te were calculated using modified delta function for the effective residual interaction. (J.W.R.)

**19287** LOW-LYING ENERGY LEVELS OF $^{116}$Sn. Sen, S.; Sinha, B. K. (Saha Inst. of Nuclear Physics, Calcutta). Proc. Nucl. Phys. Solid State Phys. Symp., 1968, Madras, 267-70(1968).

From Nuclear Physics and Solid State Physics Symposium, Madras, India. See CONF-680212.

Energy levels and $\gamma$ transition probabilities for $^{116}$Sn were calculated using the delta function interaction and taking 1p-1h neutron states as a basis. The results were compared with experimental data. (J.W.R.)

**19288** INTERMEDIATE-COUPLING MODEL FOR ODD CADMIUM ISOTOPES. Chalapati Rao, K. V. (Saha Inst. of Nuclear Physics, Calcutta). Proc. Nucl. Phys. Solid State Phys. Symp., 1968, Madras, 257-9(1968).

From Nuclear Physics and Solid State Physics Symposium, Madras, India. See CONF-680212.

The phonon-particle intermediate-coupling model was used to calculate coupling strengths and effective single-particle spacings for some odd-A cadmium isotopes. (J.W.R.)

**19289** DECAY OF $^{139}$Sm, $^{140}$Sm, $^{139}$Pm, $^{140g}$Pm AS WELL AS $^{142}$Pm. Bleyl, H.-J.; Muenzel, H.; Pfennig, G. (Kernforschungszentrum, Karlsruhe, Ger.). Radiochim. Acta, 10: 106-7(1968). (In German).

The isotopes $^{139}$Sm, $^{140}$Sm, $^{139}$Pm, $^{140g}$Pm, and $^{142}$Pm were prepared and separated, and the $\beta$ decay and $\gamma$ radiation were measured with a NaI detector. The half-lives, decay energy of the $\gamma$ quanta, and the relative frequency were determined; and the results are tabulated. (J.S.R.)

**19290** $I^2(I+1)^2$ CORRECTIONS TO ROTATIONAL SPECTRA IN ODD-A NUCLEI. Hamamoto, Ikuko (Univ. of Copenhagen); Udagawa, Takeshi. Nucl. Phys., A126: 241-60(1969).

The rotational parameter B, which is the coefficient of a term proportional to $(I(I+1)-K^2)^2$ in the expansion of the rotational spectrum, is calculated for low-lying bands of odd-A nuclei, based on the cranking model and the Nilsson model including the pairing force. Calculated B-parameters are found to agree very well with observed ones both in their signs and in their magnitudes. (auth)

**19291** ANGULAR NEUTRON CORRELATIONS FOR THE (n,2n) REACTIONS ON Pb AND Bi NUCLEI. Voitenko, V. A.; Prokopets, G. A.; Strizhak, V. I. (Kiev State Univ.). Yadern. Fiz., 9: 9-11(Jan. 1969). (In Russian).

Neutron angular distributions for the (n,2n) reactions on Pb and Bi nuclei were measured in the interval of angles $\alpha$ = 13 to 180° between the directions of the neutrons while the direction of one of the neutrons was fixed at $\theta_{II}$ = 65° to the initial neutron flux. The incident neutron energy was 14 MeV. (auth)

**19292** ENERGY AND MASS DISTRIBUTION OF FRAGMENTS FROM FAST NEUTRON FISSION OF $^{238}$U. Artemev, Yu. M.; Baranov, I. A.; Gromov, A. V.; Protopopov, A. N.; Shiryaev, B. M. Yadern. Fiz., 9: 19-22(Jan. 1969). (In Russian).

Mass spectra of fragments from fission of $^{238}$U by 14.8-MeV neutrons were measured for various total kinetic energies. (auth)

**19293** LONG-RANGE PARTICLES WITH Z ≥ 2 AT THERMAL-NEUTRON TERNARY FISSION OF $^{239}$Pu. Andreev, V. N.; Nedopekin, V. G.; Rogov, V. I. (Inst. of Theoretical and Experimental Physics, Moscow). Yadern. Fiz., 9: 23-8(Jan. 1969). (In Russian).

Emission of particles with Z ≥ 2 from thermal-neutron ternary fission of $^{239}$Pu was investigated. The particles were registered by a many-layer ionization chamber with a grid. The specific ionization, energy, and range of a particle were measured simultaneously. The nuclei of Li, Be, B, and C were detected with yields from $4.4 \times 10^{-6}$ up to $1.2 \times 10^{-7}$ nuclei per fission. The energy spectra of the ions were measured and their isotope contents were estimated. The spectra of the ions at the very moment of their emission from the fission were calculated. (auth)

**19294** COMPARATIVE MEASUREMENTS OF THE CHARACTERISTIC K EMISSION IN $^{235}$U FISSION. Davydov, Yu. P.; Solovev, S. M.; Eismont, V. P. Yadern. Fiz., 9: 29-31(Jan. 1969). (In Russian).

The data on the K emission of fragments from the thermal neu-

tron fission of $^{239}U$ were obtained and discussed in terms relative to $^{235}U$ measurements. (auth)

**19295** ELASTIC SCATTERING OF DEUTERONS ON ATOMIC NUCLEI IN THE REGION N = 82. Sokolov, L. S.; Tokarevskii, V. V.; Chernov, I. P.; Yatis, A. A. (Tomsk Order of Labor Red Banner Polytechnic Inst., USSR). Yadern. Fiz., 9: 12-15(Jan. 1969). (In Russian).

Differential cross sections of 13.6-MeV deuteron elastic scattering on the atomic nuclei $^{128}Te$, $^{133}Cs$, $^{138}La$, Ce, $^{141}Pr$, Nd, Sm, $^{165}Ho$, Yb and $^{175}Lu$ in the angle region 10 to 170° were measured. Anomalies in the value of the oscillation amplitude and of the total cross section of elastic scattering for the nuclei with N = 82 ($^{139}La$, Ce, $^{141}Pr$) as well as a decrease of cross sections on the strongly deformed nuclei Sm and $^{175}Lu$ were found in the angular distributions. Scattering irregularities may be due to specific features, i.e., shell structure, level density, and deformation. (auth)

**19296** NUCLEON AND NUCLEON-GROUP TRANSFER REACTIONS INDUCED IN THE BOMBARDMENT OF $^{197}Au$ AND $^{232}Th$ BY $^{12}C$, $^{14}N$, AND $^{15}N$ PROJECTILES. Volkov, V. V.; Gridnev, G. F.; Zorin, G. N.; Chelnokov, L. P. (Joint Inst. for Nuclear Research, Dubna, USSR). Nucl. Phys., A126: 1-14(1969).

Targets of $^{197}Au$ and $^{232}Th$ were bombarded by $^{12}C$, $^{14}N$ and $^{15}N$ projectiles at 82, 110 and 98.5 MeV, respectively. Differential cross sections and energy spectra were measured for the transfer of one proton, one neutron, a deuteron, $^{3}He$, and $^{4}He$. The angular distributions of all transfer reactions have a peak at the angle corresponding to the Rutherford scattering of two nuclei by grazing collision. The cross section of the few-nucleon transfer differs only slightly from that of the single-nucleon transfer. The energy spectra of the $^{3}He$ transfer were narrower than those of the proton transfer. These results indicate the possibility of cluster level excitation by the few-nucleon transfer. The $^{4}He$ pick-up cross section was smaller than a few μb; it is possible that the alpha particle enters the unbound levels of the projectiles. (auth)

**19297** L AND M SUBSHELL RATIOS OF THE 43.5-keV E2 TRANSITION IN $^{234}U$. Amtey, S. R. (Vanderbilt Univ., Nashville); Hamilton, J. H.; Ramayya, A. V.; Mladjenovic, M. M.; Alton, G. Nucl. Phys., A126: 201-8(1969).

The subshell ratios of the $2^+ \rightarrow 0^+$ 43.5-keV E2 transition in $^{234}U$ from the α decay of $^{238}Pu$ were measured in an iron-free $\pi\sqrt{2}$ spectrometer. The following results with errors in parentheses were obtained for the $L_I/L_{II}/L_{III}$, $M_I/M_{II}/M_{III}/M_{IV+V}$, $N_{II}/N_{III}$, M/N + ..., N/O + ... and $L_{III}/M$ ratios, respectively: 3.99(22)/114.70(20)/100, 4.2(8)/104(5)/100/2.0(8), 1.10(10), 3.10(15), 4.34(60) and 1.65(4). The L-subshells agree well with the calculations of Sliv and Band, of Hager and Seltzer and of Pauli and the M-subshells with the calculations of the latter two groups. (auth)

**19298** GROUND AND EXCITED STATE DEFORMATIONS IN THE 50 < Z, N < 82 REGION. Arsenev, D. A.; Sobiczewski, A.; Solovev, V. G. (Joint Inst. for Nuclear Research, Dubna, USSR). Nucl. Phys., A126: 15-35(1969).

The dependence of the ground-state energy on beta and gamma deformations for neutron-deficient nuclei with 50 < Z, N < 82 is studied. Even, odd, and doubly odd nuclei are investigated. The equilibrium deformations and the deformation energies are calculated. It is found that the energy minimum occurs at axially symmetric shapes, either oblate (γ = 60°) or prolate (γ = 0°). As a function of the beta deformation, the energy has two minima, as a rule close in energy; one for positive and the other for negative value of beta. When going via gamma deformation no significant barrier between the two minima is found, suggesting a softness of the nuclei to gamma deformation. Quasiparticle excited states are also studied. A possibility for shape isomers is obtained. (auth)

**19299** INTERACTION OF 14.7-MeV NEUTRONS WITH $^{238}U$ AND $^{232}Th$. Boschung, P.; Gagneux, St.; Hoop, B. Jr.; Huber, P.; Lewandowski, Z.; Wagner, R. (Univ., Basel). Helv. Phys. Acta, 42: 225-51(Apr. 1, 1969). (In German).

The neutron spectra resulting from the bombardment of $^{232}Th$ and uranium by 14.7-MeV neutrons were measured with a time-of-flight equipment using the associated particle method. Nuclear temperatures, from the analysis of the inelastic part of the spectra, are: 720 ± 70 keV for $^{232}Th$ and (850 ± 80) keV for $^{238}U$. The discrepancies at a mean excitation energy of approximately 13 MeV among the earlier experimental results are explained by the different ways of subtracting the spectrum of the postfission neutrons. The level density parameters, based on the Fermi-gas model including pairing and shell effects, were found to be $a_f' = 27 \pm 5$ $MeV^{-1}$ for $^{232}Th$ and $a_f' = 20.5 \pm 4$ $MeV^{-1}$ for $^{238}U$. They are in agreement with results from experiments at lower neutron energies. The evaporation distributions were analyzed in terms of the Lang and Le Couteur spectra. A Monte Carlo program was developed and successfully used to calculate the spectrum distortions due to multiple interactions in the scattering samples. The inverse cross sections appearing in the evaporation spectra were represented by optical model values. (auth)

**19300** ANGULAR ANISOTROPY OF FISSION OF $^{238}Pu$ BY NEUTRONS. Shpak, D. L.; Smirenkin, G. N. JETP Lett. (USSR) (Engl. Transl.), 8: 332-4(Nov. 20, 1968).

Translated from Zh. Eksp. Teoret. Fiz., Pis'ma Redaktsiyu, 8: 545-8(Nov. 20, 1968).

The angular distribution of fragments from the neutron fission of $^{238}Pu$ was measured from threshold up to 5 MeV using cylindrical glass detectors. The results agree, within the limits of errors, with the relation $W(\theta)/W(90°) = 1 + A\cos^2\theta$, which follows from the statistical theory of the angular anisotropy of fission. The data also show that the rate of change of the angular anisotropy coefficient A does not decrease with increasing neutron energy. (D.C.W.)

**19301** UNIFIED-MODEL CALCULATIONS FOR $^{139}Ce$. Heyde, K.; Vanden Berghe, G. (Rijksuniversiteit, Ghent). Nucl. Phys., A126: 381-91(1969).

The energy spectrum of the odd-neutron nucleus $^{139}Ce$ is described in a unified model in intermediate coupling. The coupling strength between phonon excitations and the neutron single-hole motion, the single-hole energies, was taken as free parameters and was determined in a least-squares fitting procedure. The wave functions were used to calculate M1 and E2 moments and transition probabilities. The lifetime of the isomeric $I^\pi = 1\frac{1}{2}^-$ level was reproduced in the model. Also spectroscopic factors for the reaction $^{140}Ce(^{3}He,\alpha)^{139}Ce$ were calculated. (auth)

**19302** CORIOLIS COUPLING BETWEEN THE $\frac{7}{2}^+[404]$ AND $\frac{5}{2}^+[402]$ BANDS IN $^{175}Lu$. Hansen, P. G.; Hornshoej, P.; Johansen, K. H. (Univ. of Aarhus, Denmark). Nucl. Phys., A126: 464-70(1969).

New experimental evidence on the M1 + E2 transitions following the beta decay of 70-day $^{175}Hf$ is presented. The absolute transition probabilities and the signs of the mixing parameters, which may be measured in directional correlation experiments, were used to derive the reduced Coriolis matrix element $A_K$ and the intrinsic inter-band M1 matrix element $G^{\frac{5}{2}\frac{7}{2}}$. The results are in good agreement with calculations based on the Nilsson Model. (auth)

**19303** MULTI-LEVEL ANALYSIS OF THE $^{235}U$ FISSION CROSS SECTION. Cramer, J. D. (Los Alamos Scientific Lab., N. Mex.). Nucl. Phys., A126: 471-80(1969).

Resonance parameters for the $^{235}U$ fission cross section, as measured on the "Petrel" experiment at the Nevada Test Site, were determined using a multi-level fitting program based on the Wigner–Eisenbud R-matrix theory. Tentative $J^\pi$ values are assigned to each level for neutron energies from 17 to 70 eV. (auth)

**19304** ENERGIES AND INTENSITIES OF $^{125}Sb$ GAMMA RAYS. Charalambus, St.; Daniel, H.; Koch, H.; Poelz, G.; Schmitt, H.; Tauscher, L.; Backenstoss, G. (CERN, Geneva. Max-Planck-Institut fuer Kernphysik, Heidelberg. Univ., Karlsruhe, Ger.). Nucl. Phys., A126: 428-30(1969).

Energies and relative intensities of $^{125}Sb$ gamma rays are reported. (auth)

**19305** PARITY MIXING IN THE 482-keV STATE IN $^{181}Ta$. Cruse, D. W.; Hamilton, W. D. (Univ. of Sussex, Brighton, Eng.). Nucl. Phys., A125: 241-56(1969).

A search was made for a parity-violating component in the 482-keV level of $^{181}Ta$ by measuring the degree of circular polarization of the ground state transition. Two Compton transmission analyzers were used. The design of the experiment required extreme care because of the small degree of polarization expected, i.e., $P_\gamma \approx 10^{-4}$, and the low efficiency of the Compton analyzers. The minimization or elimination of possible causes of a false effect is discussed; control experiments with $^{60}Co$ and $^{181}Hf$ sources were used to evaluate any residual asymmetry in the measuring system. Considerable care was taken in the analysis of the data especially as regards the removal of trend effects. A careful investigation of the various sources of systematic error was made; the only significant one found was due to bremsstrahlung. The results obtained were $P_\gamma = -0.8 \pm 1.4 \times 10^{-4}$ (analyzer efficiency 0.6%) and $P_\gamma = -0.9 \pm 0.6 \times 10^{-4}$ (analyzer efficiency 1.6%). The second result is significantly larger than the calculated effect due to bremsstrahlung ($P_\gamma = -1.6 \times 10^{-5}$). It is consistent with the theoretical estimates, which lie in the range $P_\gamma = -0.4$ to $2.7 \times 10^{-4}$. (auth)

**19306** A SEARCH FOR INTERMEDIATE STRUCTURES IN TOTAL NEUTRON CROSS-SECTION OF Gd. Hussain, M. (Univ. of Dacca, Pakistan); Islam, E.; Ameen, N. Nucl. Sci. Appl., Ser. B, 4: 3-7(Oct. 1968).

In order to look at the possible existence of intermediate structures, total neutron cross-section measurements were made for Gd. The transmission method with ZnS plastic scintillator gave results with a statistical accuracy of the order of 3%. The energy resolution was of the order of 20 keV. Measurements were made over the energy range of 1 to 2 MeV in steps of about 25 keV. Structures seem to appear with amplitudes ~7% only and widths ~60 keV. (auth)

**19307** DECAY OF $^{111}$Pd AND $^{111m}$Pd. Berzins, G.; Bunker, M. E.; Starner, J. W. (Los Alamos Scientific Lab., N. Mex.). Nucl. Phys., A126: 273-99(1969).

The energy levels of $^{111}$Ag were investigated through study of the decay of 22-min $^{111}$Pd and 5.5-hr $^{111m}$Pd using high-resolution Ge(Li) and Si(Li) spectrometers and a 30-cm$^3$ Ge(Li), 45-cm$^3$ Ge(Li) coincidence system. More than 150 gamma transitions were observed from the two isomers. The coincidence results, in conjunction with energy sums and relative-intensity considerations, suggest a $^{111}$Ag level scheme involving 48 energy levels below 2.2 MeV. On the basis of beta and gamma selection rules, unique spin-parity assignments were suggested for a number of the established levels. The 74 sec first excited state in $^{111}$Ag was shown to independently beta decay to several excited states in $^{111}$Cd. It was noted that there are many similarities in the level structures of $^{111}$Ag, $^{109}$Ag and $^{107}$Ag. These nuclei seem reasonably well described by the particle-phonon coupling model; however, it also appears possible that certain groups of levels are rotational in character. (auth)

**19308** LIFETIMES OF ROTATIONAL STATES FROM HEAVY-ION REACTIONS. Diamond, R. M.; Stephens, F. S.; Kelly, W. H.; Ward, D. (Univ. of California, Berkeley). Phys. Rev. Lett., 22: 546-50(Mar. 17, 1969).

The half-lives of several transitions in the ground-state collective bands of $^{160}$Er, $^{158}$Er, and $^{156}$Er produced by ($^{40}$Ar,4n) reactions were measured by a recoil-distance Doppler-shift method. These lifetimes are compared with those of several models. The mean time interval between the reaction and the population of the ground band was also determined. (auth)

**19309** INVESTIGATION OF SINGLE-PARTICLE CORE-EXCITATION COUPLING IN THE STRONTIUM AND LEAD REGIONS. Zawischa, D.; Werner, E. (Technische Univ., Hanover). Nucl. Phys., A125: 383-401(1969).

The nuclei neighboring $^{88}$Sr and $^{208}$Pb are treated as a core plus an additional particle or hole interacting with the core vibrations. With the help of the Green function technique the core vibrations are described as collective particle-hole excitations thus depending on the single-particle propagators. An iterative calculation was performed for $^{88}$Sr, showing that the coupling of single-particle and collective modes is very important. Because of angular momentum coupling and parity selection rules the coupling possibilities are strongly reduced in the lead region. (auth)

**19310** NEW ISOMERIC STATE IN $^{118}$In. Hattula, J. (Univ. of Helsinki); Liukkonen, E.; Kantele, J. Nucl. Phys., A125: 477-80(1969).

A new 8.5 ± 0.3 s isomeric state having spin 7$^-$ or 8$^-$ is assigned to $^{118}$In. The isomer decays with a 138.2-keV (E3) $\gamma$ transition to the 4$^+$ or 5$^+$ 4.4-min isomer and via an allowed beta transition to a 7$^-$ state in $^{118}$Sn. (auth)

**19311** FRAGMENT DISTRIBUTIONS IN THE FISSION OF $^{232}$Th BY PROTONS OF ENERGIES 13 TO 53 MeV. Croall, I. F.; Cuninghame, J. G. (Atomic Energy Research Establishment, Harwell, Eng.). Nucl. Phys., A125: 402-16(1969).

Mass and kinetic energy distributions were obtained for $^{232}$Th fissioned by protons of energies 13, 20, 27, 35, 40, 45, and 53 MeV by measuring energies of coincident pairs of fission fragments in gold surface-barrier detectors. The data are displayed in various ways with the main object of showing the effect of increase in excitation energy of the compound nucleus. Most parameters are affected in a uniform and probably monotonic way. The data favor the two-mode of fission hypothesis over the fragment shell theory. (auth)

**19312** EVIDENCE FOR A 9/2$^-$ [505] ISOMERIC STATE IN $^{193}$Os. Bisgard, K. Maack; Hanson, R. J. (Univ. of Aarhus, Denmark). Nucl. Phys., A125: 305-11(1969).

The 11/2$^-$ [505] state at 80 keV in $^{193}$Ir is populated after neutron capture in $^{192}$Os. It is concluded that the feeding occurs from an isomeric state in $^{193}$Os with a half-life of 17 ± 1 min. The capture cross section is about 14 mb. The isomeric state is interpreted as being the 9/2$^-$ [505] state. The log ft value for the 9/2$^-$ [505] → 11/2$^-$ [505] transition is greater than 4.9 and probably smaller than 5.2. (auth)

**19313** INELASTIC SCATTERING OF NEUTRONS TO THE 59-keV LEVEL OF $^{127}$I. Bain, C. A. R.; Brooks, F. D. (Univ. of Cape Town). Nucl. Phys., A125: 312-20(1969).

The excitation of the 59-keV level of $^{127}$I by neutron inelastic scattering was studied using a small NaI scintillation crystal as both target and detector. Measurements were carried out in the incident neutron energy range 50 to 500 keV, and the neutron flux incident on the crystal was monitored with a $^6$Li loaded glass scintillator. The cross sections obtained are compared with those calculated from Hauser–Feshbach theory. (auth)

**19314** SEMI-REALISTIC STRUCTURE CALCULATIONS IN THE LEAD REGION. Freed, N.; Rhodes, W. (Pennsylvania State Univ., University Park). Nucl. Phys., A126: 481-504 (1969).

A model for carrying out nuclear-structure calculations is proposed which lies intermediate between the microscopic and the phenomenological approaches. The first-order interaction is taken to be the non-local Tabakin potential with core polarization effects simulated by additional pairing-plus-quadrupole forces. A discussion of our approximations as well as the results of a shell-model calculation on the eight nuclei having a $^{208}$Pb core ±2 nucleons is presented. The results are very good compared either to phenomenological calculations or to experiment. (auth)

**19315** ($\gamma$,n) REACTIONS IN THE ENERGY RANGE 1.0 TO 5.5 GeV. De Carvalho, H. G. (Centro Brasileiro de Pesquisas Fisicas, Rio de Janeiro); Di Napoli, V.; Margadonna, D.; Salvetti, F.; Tesch, K. Nucl. Phys., A126: 505-12(1969).

The ($\gamma$,n) cross sections per equivalent quantum of $^{12}$C, $^{103}$Rh, $^{127}$I, $^{197}$Au, and $^{238}$U were measured with a bremsstrahlung beam of maximum energies in the range 1 to 5.5 GeV. Within the experimental errors of the activation method, no contribution of photons above 1 GeV was found. This result disagrees with some previous measurements at energies below 1 GeV but agrees with the predicted values obtained from simple theoretical estimates. (auth)

**19316** PARTICLE–VIBRATION COUPLING IN THE NUCLEI $^{209}$Bi AND $^{209}$Pb. Hamamoto, Ikuko (Univ. of Copenhagen). Nucl. Phys., A126: 545-61(1969).

The particle-vibration (3$^-$) coupling in the nuclei $^{209}$Bi and $^{209}$Pb is investigated by solving the differential equations. It is able to explain most of the characteristic features of the particle-vibration states in both nuclei. Especially, the calculation can give accurate information on the one-particle structure of the particle-vibration states. (auth)

**19317** LIFETIME AND MAGNETIC MOMENT OF THE 36.2 keV LEVEL OF $^{189}$Os. Wagner, F.; Kaindl, G.; Bohn, H.; Biebl, U.; Schaller, H.; Kienle, P. (Technische Hochschule, Munich). Phys. Lett., 28B: 548-50(Feb. 3, 1969).

The recoilless nuclear resonance absorption of the 36.2 keV $\gamma$ rays of $^{189}$Os was observed. The lifetime $\tau$ = 0.72 ± 0.04 ns and the magnetic moment $\mu$ = +0.226 ± 0.029 nm of the 36.2 keV state ($I^\pi$ = 1/2$^-$) were determined. (auth)

**19318** SEARCH FOR ELEMENT 110 IN PLATINUM ORE VIA NEUTRON-INDUCED FISSION. Wesolowski, J. J.; Jewell, W. J. R.; Guy, F. (Univ. of California, Livermore). Phys. Lett., 28B: 544-5(Feb. 3, 1969).

Recent theoretical calculations suggest that an isotope of element 110 might exist in earthly matter. A search was made for element 110 in Pt ore by observing neutron-induced fission. An upper limit of $6 \times 10^{-12}$ is placed on the abundance of element 110 in the ore. (auth)

## Nuclear Theory

*Refer also to abstracts 17789, 18399, 18752, 18767, 18844, 18878, 19015, 19024, 19141, 19148, 19149, 19154, 19160, 19164, 19165, 19167, 19169, 19174, 19185, 19190, 19192, 19199, 19201, 19206, 19212, 19222, 19230, 19243, 19251, 19252, 19271, 19290, 19301, 19309, 19314, and 19316.*

**19319** (AERE-R-5744) CONFERENCE ON LOW AND MEDIUM ENERGY NUCLEAR PHYSICS AT A.E.R.E., Harwell, 27th–29th MARCH 1968. Currie, W. M. (ed.) (Atomic Energy Research Establishment, Harwell (England)). Mar. 1968. 83p. (CONF-680321). Dep. CFSTI, UK.

Outlines of contributed papers and invited talks dealing with resonance reactions; gamma spectroscopy; techniques, apparatus, and instrumentation; nuclear spectroscopy; theoretical topics; medium-energy work; computer programs; and testing of cosmological theories are presented. (D.C.W.)

**19320** (AERE-R-5891) STRUCTURE IN SUB-THRESHOLD FISSION MODES. Lynn, J. E. (Atomic Energy Research Establishment, Harwell (England)). Sept. 1968. 61p. Dep. CFSTI. UK 8s. 0d.

The available experimental evidence for gross structure in subthreshold fission is summarized, and a theoretical interpretation of the narrow intermediate structure observed in resonance cross sections is developed. An analysis of data on narrow intermediate structure is outlined, and damping and coupling parameters are discussed in terms of the double minimum in the potential energy of deformation calculated by Strutinsky in theoretical studies of shell effects in the deformation energy of nuclei. (D.C.W.)

**19321** (ANU-P-424) ON THE EFFECT OF THE STATISTICAL COMPOUND NUCLEUS PROCESS IN ELASTIC SCATTERING MEASUREMENTS. Dallimore, P. J. (Australian National Univ., Canberra. Research School of Physical Sciences). [1969]. 9p. Dep.

The errors in elastic scattering cross-section calculations due to a statistical compound-nucleus component are investigated. It is found that the spin of the target nucleus is a major parameter in the estimation of these errors. (auth) (AUSTRALIA)

**19322** (BNL-13297) EFFECT OF RESIDUAL INTERACTIONS: ANALOGUE STATE ENERGIES, NEUTRON RADII. Auerbach, E.; Kahana, S.; Scott, C. K.; Weneser, J. (Brookhaven National Lab., Upton, N. Y.). [1967]. 5p. (CONF-690310-1). Dep. CFSTI.

From Conference on Isobaric Spin, Pacific Grove, Calif.

The effect of the residual interactions on the Coulomb energy separation between analog states is examined in the same spirit and accuracy with which residual interactions are handled in nuclear physics. A closed form expression allows for simple calculational procedures. Comparison can be made with other prescriptions for including the effects of changes in binding. The dependence on the form of the residual interaction is explored. (auth)

**19323** (BNL-tr-246) COEFFICIENTS OF ANGULAR CORRELATION OF DIPOLE AND QUADRUPOLE GAMMA TRANSITIONS. Lobov, G. A. Translated by Stephen J. Amoretty (Brookhaven National Lab., Upton, N. Y.), from Izv. Akad. Nauk SSSR, Ser. Fiz., 32: 886-91(1968). 11p. Dep. CFSTI.

An abstract of this paper, prepared from the original language, appeared as NSA 22: 44750.

**19324** (CEA-R-3645) INTRINSIC BOUND STATES OF NUCLEONS IN HIGHLY DEFORMED NUCLEI. Supplement to Nilsson's Model. Houviez, Jacqueline (Commissariat a l'Energie Atomique, Limeil-Brevannes (France). Centre d'Etudes Nucleaires). Dec. 1968. 91p. (In French). Dep.

Thesis.

A computer program for calculating the energies and components of the intrinsic states of nucleons in the Nilsson model for deformed nuclei is formulated. The contributions of shells with different N, which were neglected by Nilsson, are introduced. The importance of these nondiagonal terms in N, due to the quadrupole deformations, is evaluated. Some applications of the method to nuclei with $131 \leq N \leq 151$ are discussed, including a test of the sensitivity of the model to the variation of the parameter $\mu$ and calculations of intrinsic states and magnetic moments. (D.C.W.)

*For abstracts of individual papers see: 18399, 18545, 18729, 19136, 19144–19146, 19165–19175, 19207–19212, 19266–19288, and 19347–19359.*

**19325** (CONF-680212) PROCEEDINGS OF THE NUCLEAR PHYSICS AND SOLID STATE PHYSICS SYMPOSIUM, MADRAS, FEBRUARY 27–MARCH 1, 1968. NUCLEAR PHYSICS. (Department of Atomic Energy, Bombay (India). Physics Committee). 1968. 415p. Dep.

Separate abstracts were prepared for 60 of the 64 papers included. (J.W.R.)

**19326** (INR-P-950) INTERNAL BREMSSTRAHLUNG IN ELECTRON CAPTURE. Zylicz, Jan (Institute of Nuclear Research, Warsaw (Poland)). 1968. 22p. (CONF-680703-5). Dep.

From International Conference on Electron Capture and Higher Order Processes in Nuclear Decay, Debrecen, Hungary.

The results of experimental and theoretical studies on the internal bremsstrahlung in electron capture are surveyed with emphasis put on the energy spectra in the case of forbidden transitions. (auth)

**19327** (ITF-68-58) SOME PROPERTIES OF NONAXIAL ODD NUCLEI. Kashuba, I. E.; Ovcharenko, V. I. (Akademiya Nauk Ukrainskoi SSR, Kiev. Institut Teoreticheskoi Fiziki). 1968. 31p. (In Russian). Dep.

In the framework of the model of nonaxial odd nuclei developed earlier by Davydov, Pashkevich, and Sardarian, sum rules for energy levels, for average values of electric quadrupole and magnetic dipole moments, and for reduced probabilities of E2 and M1 transitions are obtained in the adiabatic approximation in $\beta$ and $\gamma$ oscillations. Numerical calculations are carried out of some reduced probabilities of E2 and M1 transitions and of average values of electric quadrupole and magnetic dipole moments; and the values obtained are compared with experimental data for the nuclei $^{165}$Ho, $^{167}$Er, $^{175}$Lu, $^{177}$Lu, $^{177}$Hf, and $^{181}$Ta. (auth)

**19328** (ITF-68-66) PROPERTIES OF ATOMIC NUCLEI AND INTERACTION BETWEEN NUCLEONS. Filippov, G. F. (Akademiya Nauk Ukrainskoi SSR, Kiev. Institut Teoreticheskoi Fiziki). 1968. 12p. (In Russian). Dep.

The problem of whether it is possible to explain the saturation observed in atomic nuclei (when coupling energy and volume are proportional to the number of nucleons) by considering only pair forces without a hard core is considered. The answer is negative. The saturation can be explained by introducing either hard-core or three-particle repulsive forces. (auth)

**19329** (JINR-P2-4160) PRODUCTION OF MULTIPLY CHARGED FRAGMENTS IN INTERACTIONS OF HIGH-ENERGY PARTICLES WITH NUCLEI. Eliseev, S. M. (Joint Inst. for Nuclear Research, Dubna (USSR). Lab. of Theoretical Physics). 1968. 60p. (In Russian). Dep.

Experimental data and various fragmentation theories in the high-energy region are reviewed. 118 references. (auth)

**19330** (ORNL-tr-2073) INTERACTION CROSS SECTIONS OF FAST PARTICLES AND ATOMIC NUCLEI. Barashenkov, V. S.; Gudima, K. K.; Toneev, V. D. Translated for Oak Ridge National Lab., Tenn., from report JINR-P2-4068. 43p. Dep. CFSTI.

An abstract of this paper, prepared from the original language, appeared as NSA 23: 5944.

**19331** (PUC-937-341) TWO-PARTICLE TRANSFER IN DEFORMED NUCLEI. Bertsch, George F. (Princeton Univ., N. J. Palmer Physical Lab.). Nov. 1968. 13p. Dep. CFSTI.

Correlations between Nilsson orbitals in deformed nuclei might profitably be studied by two-nucleon transfer reactions. Variations in transfer strength by factors of ~30 were obtained in a crude calculation for strengths to different states in typical reactions. It turns out that the momentum correlation between the particles transferred is much more important than spacial correlation of the orbitals in producing large transfer strengths. (auth)

**19332** (RHEL/R-166) PROCEEDINGS OF THE SYMPOSIUM ON THE USE OF NIMROD FOR NUCLEAR STRUCTURE PHYSICS, 21st–23rd MARCH 1968. Batty, C. J. (ed.) (Rutherford High Energy Lab., Chilton (England)). June 1968. 162p. (CONF-680314). Dep. CFSTI. UK 15s.

Separate abstracts were prepared for each of the ten papers included. (J.W.R.)

*For abstracts of individual papers see: 18925, 19141, 19160, and 19333–19339.*

**19333** (RHEL/R-166, pp 7-17) NUCLEAR PHYSICS AT HIGH ENERGIES. Elton, L. R. B. (Surrey Univ., London (England). Dept. of Physics).

The current status in theoretical and experimental studies of nuclear structure and nuclear forces is described. Theories concerning the neutron and proton radii of nuclei are discussed in detail. The use of high-energy experiments for studying these theories is suggested. (J.W.R.)

**19334** (RHEL/R-166, pp 19-32) EXPERIMENTS USING HIGH-ENERGY PROTONS. Palevsky, H. (Brookhaven National Lab., Upton, N. Y.).

Experiments in nuclear structure performed with the Brookhaven Cosmotron are reviewed. Some recently reported data on (p,2p) reactions and quasi-free scattering are given. (J.W.R.)

**19335** (RHEL/R-166, pp 33-9) INVESTIGATION OF THE NUCLEAR SURFACE. Elton, L. R. B.; Jackson, Daphne F. (Surrey Univ., London (England). Dept. of Physics).

Experimental methods which might be suitable for the study of the nuclear surface region are discussed. It is concluded that interactions of high-energy protons or pions with nuclei would yield the most information. (J.W.R.)

**19336** (RHEL/R-166, pp 41-65) THEORETICAL ASPECTS OF EXPERIMENTS USING HIGH-ENERGY PROTONS. Glauber, R. J. (Harvard Univ., Cambridge, Mass. Dept. of Physics).

The theory of nuclear reactions involving high-energy proton beams is discussed. Diffraction theory is discussed in detail, and the simplicity of high-energy reactions in respect to low-energy reactions is pointed out. (J.W.R.)

**19337** (RHEL/R-166, pp 67-79) MULTIPARTICLE REACTIONS. Zupancic, C. (European Organization for Nuclear Research, Geneva (Switzerland)).

Some recent developments in the study of multiparticle reactions are discussed. Some measurements on the $(\pi^+,2p)$ reaction at high energies are described. Some suggestions for the use of high-energy beams in multiparticle reaction studies are presented. (J.W.R.)

**19338** (RHEL/R-166, pp 103-19) THEORETICAL ASPECTS OF PION REACTIONS. Ericson, T. E. O. (European Organization for Nuclear Research, Geneva (Switzerland)).

The theory of pion reactions with nuclei is discussed, and the interrelation between nuclear structure and elementary particle physics is noted. (J.W.R.)

**19339** (RHEL/R-166, pp 129-40) $K^-$-MESON ABSORPTION. Wilkinson, D. H. (Oxford Univ. (England)).

Properties of the absorption of negative K-mesons by nuclei are summarized. Experimental data and theoretical arguments on x-ray emission are discussed. In addition kaon capture by protons and neutrons, nucleon correlations, nuclear deformation, and isotope effects are discussed. (J.W.R.)

**19340** (UCRL-18715) ISOSPIN STRUCTURE OF PAIRING VIBRATIONS. Soerensen, Bent (California Univ., Berkeley. Lawrence Radiation Lab.). Jan. 1969. Contract W-7405-eng-48. 8p. (CONF-690310-2). Dep. CFSTI.

From Conference on Isobaric Spin, Pacific Grove, Calif.

The possible existence of an isospin structure in collective pairing-type excitations is discussed in connection with the confrontation of experimental data and a reliable pairing force calculation which neglects isospin structure. Evidence for the isospin structure suggested by Bohr is found in C, Mg, Si, Ti, and Ni isotopes. (auth)

**19341** (UCRL-71145) PHENOMENOLOGICAL ANALYSES OF (p,p) AND (n,p) DATA UP TO 750 MeV. MacGregor, Malcolm H. (California Univ., Livermore. Lawrence Radiation Lab.). June 1968. 18p. (CONF-680646-1). Dep. CFSTI.

From Meeting on Nucleon-Nucleon and Pion-Nucleon Interactions, Dubna, USSR.

A phase-shift analysis of the available (p,p) and (n,p) scattering data in the energy region below 750 MeV was performed. Energy-dependent analyses were carried out in the energy ranges from 0 to 400 MeV and from 0 to 750 MeV. Single-energy analyses were carried out in narrow energy bands centered at 25, 50, 95, 142, 210, 330, 425, and 630 MeV. (auth)

**19342** APPLICATION OF CURRENT COMMUTATION RELATIONS TO NUCLEAR PHYSICS. Kim, Chung Wook (Johns Hopkins Univ., Baltimore). New Phys. (S. Korea), Suppl., 7: No. 2, 34-8(June 1968).

Various applications of equal-time current commutation relations to problems in nuclear physics are reviewed. Sum rules in $\beta$ decay, the total muon capture rate in $^3$He, sum rules in forward $\nu_\mu$ scattering cross sections for nuclei, and photoproduction of pions from nuclei are discussed. (D.C.W.)

**19343** CONSERVATION LAWS AND RESIDUAL INTERACTION IN NUCLEI. Mikeska, H. J. (Univ. of Maryland, College Park); Brenig, W. Z. Phys., 220: 321-9(1969).

Relations between single-particle energies and parameters of the residual interaction in nuclei, which follow from galilean and and gauge invariance are discussed. Restrictions are given for the exchange coefficients in a phenomenological interaction and for some interaction parameters of the Fermi liquid theory. (auth)

**19344** ON SOME PROPERTIES OF THE SURFACE DELTA INTERACTION. Vucetich, H.; Plastino, A.; Krmpotic, F. (La Plata Univ. Nacional). Z. Phys., 220: 218-28(1969).

A method is discussed for solving the RPA equations without discarding any term in the case of separable interactions. It is specialized to the SDI for both spherical and deformed nuclei and applied in two simple examples. (auth)

**19345** EFFECT OF PARTICLE EXCHANGE IN NUCLEAR REACTIONS. Borbei, I.; Dolinskii, E. I. ((Moscow State Univ.). Acta Phys. Acad. Sci. Hung., 25: 141-6(1968). (In Russian).

Starting from the general formulas of Ekstein which take into account the effect of antisymmetrization, useful expressions are given for the amplitudes of nuclear reactions containing two nuclei both in the initial and final states. (auth)

**19346** TRIPLET-ODD NUCLEON-NUCLEON INTERACTION AND SPIN-ORBIT SPLITTING. Pearson, J. M.; Saunier, G.; Trudeau, F.; Desgrolard, P. (Univ. of Montreal). Can. J. Phys., 47: 823-6(Apr. 1, 1969).

Three different triplet-odd N-N potentials, all of which have some measure of conformity to meson theory, are shown to lead to approximately correct spin-orbit splittings in several dcs ± 1 nuclei. (auth) (Canada)

**19347** SUM RULE FOR PARTICLE REACTIONS ON NUCLEI. Ramachandran, G. (Indian Statistical Inst., Calcutta). Proc. Nucl. Phys. Solid State Phys. Symp., 1968, Madras, 401(1968).

From Nuclear Physics and Solid State Physics Symposium, Madras, India. See CONF-680212.

A generalized sum rule for particle reactions with nuclei, which is particularly applicable to electron scattering, was developed. (J.W.R.)

**19348** NUCLEAR STRUCTURE CALCULATION WITH REALISTIC TWO-NUCLEON POTENTIAL. Pal, M. K. (Saha Inst. of Nuclear Physics, Calcutta). Proc. Nucl. Phys. Solid State Phys. Symp., 1968, Madras, 1-16(1968).

From Nuclear Physics and Solid State Physics Symposium, Madras, India. See CONF-680212.

Various realistic two-nucleon potentials used in nuclear structure calculations are discussed. (J.W.R.)

**19349** NUCLEAR STRUCTURE CALCULATIONS. Lawson, R. D. (Argonne National Lab., Ill. Weizmann Inst. of Science, Rehovoth, Israel). Proc. Nucl. Phys. Solid State Phys. Symp., 1968, Madras, 17-31(1968).

From Nuclear Physics and Solid State Physics Symposium, Madras, India. See CONF-680212.

The particular qualities of shell-model nuclear states that make them amenable to the BCS approximation are discussed, and exact calculations for some nickel isotopes are compared with BCS calculations. (J.W.R.)

**19350** ELEMENTARY PARTICLES AND NUCLEAR STRUCTURE. Banerjee, B. (Tata Inst. of Fundamental Research, Bombay). Proc. Nucl. Phys. Solid State Phys. Symp., 1968, Madras, 32-41(1968).

From Nuclear Physics and Solid State Physics Symposium, Madras, India. See CONF-680212.

The use of pion reactions with nuclei for studying nuclear structure is discussed. Methods for treating absorption, elastic scattering, radiative capture, and charge-exchange reactions are reviewed. (J.W.R.)

**19351** ISOSPIN IMPURITIES OF LOW-LYING NUCLEAR STATES. Mitra, S. K. (Tata Inst. of Fundamental Research, Bombay). Proc. Nucl. Phys. Solid State Phys. Symp., 1968, Madras, 42-61(1968).

From Nuclear Physics and Solid State Physics Symposium, Madras, India. See CONF-680212.

Information on isospin impurities in low-lying nuclear states, derived from beta decay experiments is described. A measurement of $\beta-\gamma$ correlations in $^{59}$Fe is reported. Some of the qualitative aspects of the charge dependence of nuclear forces obtained from beta decay studies are discussed. (J.W.R.)

**19352** RECENT ADVANCES IN NUCLEAR FISSION STUDIES. Kapoor, S. S. (Bhabha Atomic Research Centre, Trombay, India). Proc. Nucl. Phys. Solid State Phys. Symp., 1968, Madras, 62-84(1968).

From Nuclear Physics and Solid State Physics Symposium, Madras, India. See CONF-680212.

Some recent advances in nuclear fission studies which are encouraging with respect to the possibility of investigating the spectroscopy of neutron-rich nuclei through the de-excitation of primary fission fragments are surveyed. Mention is also made about the uniqueness of the fission process in offering a way to study nuclei in a state of unusually large deformation. The effect of closed nuclear shells on the fission barrier heights is discussed with regard to its consequences on the assumed instability of superheavy nuclei. (J.W.R.)

**19353** DIVISION OF NUCLEAR CHARGE IN LOW-ENERGY FISSION OF HEAVY NUCLEI. Ramanna, R.; Ramamurthy, V. S. (Bhabha Atomic Research Centre, Trombay, India). Proc. Nucl. Phys. Solid State Phys. Symp., 1968, Madras, 298-301(1968).

From Nuclear Physics and Solid State Physics Symposium, Madras, India. See CONF-680212.

The stochastic theory of fission was generalized to include the division of nuclear charge in order to explain charge division in low-energy fission of heavy nuclei. (J.W.R.)

**19354** CALCULATION OF ABSOLUTE SINGLE-PARTICLE ENERGIES IN A SAXON-WOODS POTENTIAL. Ramakrishna, G.

(Saha Inst. of Nuclear Physics, Calcutta). Proc. Nucl. Phys. Solid State Phys. Symp., 1968, Madras, 274-6(1968).

From Nuclear Physics and Solid State Physics Symposium, Madras, India. See CONF-680212.

Neutron single-particle states in a Saxon–Woods potential were calculated for $^{209}$Pb. The variable parameters were adjusted to fit the experimental data, and the Schroedinger equation was solved numerically by the Runge–Kutta method. (J.W.R.)

**19355** SEMI-CLASSICAL FORMULATION OF COLLECTIVE STATES OF FINITE NUCLEI. Warke, Chindhu S. (Tata Inst. of Fundamental Research, Bombay). Proc. Nucl. Phys. Solid State Phys. Symp., 1968, Madras, 244-6(1968).

From Nuclear Physics and Solid State Physics Symposium, Madras, India. See CONF-680212.

The semiclassical formulation of collective states of finite nuclei is described. The validity of the model for describing certain properties is discussed. (J.W.R.)

**19356** STATISTICAL MOMENTS OF PURELY ELASTIC SCATTERING. Ullah, Nazakat; Sandhya Devi, K. R. (Tata Inst. of Fundamental Research, Bombay). Proc. Nucl. Phys. Solid State Phys. Symp., 1968, Madras, 237-40(1968).

From Nuclear Physics and Solid State Physics Symposium, Madras, India. See CONF-680212.

Expressions were derived for the lower moments of the unitary collision matrix, and hence the cross section, for purely elastic scattering. It is shown that in the limiting case of small $< \Gamma >/D$, the expressions reduced to those derived previously. (J.W.R.)

**19357** SPECTRAL AVERAGES IN TRANSFER REACTIONS INVOLVING TARGETS WITH SINGLE ACTIVE SHELL. Bansal, Ram K. (Tata Inst. of Fundamental Research, Bombay). Proc. Nucl. Phys. Solid State Phys. Symp., 1968, Madras, 229-32(1968).

From Nuclear Physics and Solid State Physics Symposium, Madras, India. See CONF-680212.

Equations were derived for the spectroscopic average of level groups resulting from stripping and pickup reactions on nuclei with single active shells. Calculations were performed for stripping reactions on $^{42,43,44,45,46,47}$Ca, and the results were compared with experiments. (J.W.R.)

**19358** EFFECTIVE INTERACTION FOR NUCLEAR SPECTROSCOPY CALCULATIONS. Mehta, G. K. (Indian Inst. of Tech., Kanpur). Proc. Nucl. Phys. Solid State Phys. Symp., 1968, Madras, 205-8(1968).

From Nuclear Physics and Solid State Physics Symposium, Madras, India. See CONF-680212.

The parameters for a phenomenological potential were found by taking the best fit to Shakin's Yale potential matrix elements. The nucleon–nucleon potential contains the conventional exchange terms for the central force and a pure Wigner type of tensor force term. Energy levels were calculated for some s-d shell nuclei using the phenomenological potential. (J.W.R.)

**19359** DIFFERENTIAL FORMS AND NUCLEAR STRUCTURE. Ramanna, R. (Bhabha Atomic Research Centre, Trombay, India). Proc. Nucl. Phys. Solid State Phys. Symp., 1968, Madras, 188-93(1968).

From Nuclear Physics and Solid State Physics Symposium, Madras, India. See CONF-680212.

It is shown that many aspects of nuclear structure can be obtained without the use of physical models by considering a set of Schroedinger equations in their differential forms defined on an appropriate Riemann manifold. Assuming a spinless stable system, binding energies and the neutron–proton ratio are properties that come out of the analysis. (J.W.R.)

**19360** MAXIMUM LIKELIHOOD ESTIMATES OF HALF-LIFE. McBride, William J. (Varian Associates, Palo Alto, Calif.). IEEE (Inst. Elec. Electron. Eng.), Trans. Nucl. Sci., NS-15: No. 6, 350-1(Dec. 1968).

From Annual Conference on Nuclear and Space Radiation Effects, Missoula, Mont. See CONF-680706.

A maximum likelihood estimate of half-life is obtained by considering the observed times of disintegration as a random sample from a truncated exponential continuous probability density function. The result is identical to that obtained by considering the individual disintegrations as discrete independent events which follow the laws of probability. (auth)

**19361** THE RANDOM PHASE APPROXIMATION AND THE SEPARATION OF COLLECTIVE DEGREES OF FREEDOM. Unna, Issachar (Hebrew Univ., Jerusalem). pp 403-9 of Spectroscopic and Group Theoretical Methods in Physics. Block, F. (ed.). New York, John Wiley and Sons, Inc., 1968.

A procedure by which any desired degree of freedom can be eliminated in the random phase approximation is outlined. The approximations involved and the basic limitations of the method are described. The method may be applied to the separation of collective degrees of freedom such as giant dipole vibrations and quadrupole vibrations. (J.W.R.)

**19362** RESIDUAL INTERACTION IN ATOMIC NUCLEI. Sliv, L. A.; Kharitonov, Yu. I. (Ioffe Inst. of Physics and Tech., Leningrad). pp 275-89 of Spectroscopic and Group Theoretical Methods in Physics. Block, F. (ed.). New York, John Wiley and Sons, Inc., 1968.

The role of the residual interaction in a system of closed shells with extra nucleons moving in a self-consistent shell-model field is treated by a method developed by Racah. (J.W.R.)

**19363** NUCLEAR THEORY: THE QUASIPARTICLE METHOD. Migdal, A. B. Frontiers in Physics. New York, W. A. Benjamin, Inc., 1968. 153p.

Translated by Anthony J. Leggett.

The quasiparticle formalism for nuclei is presented in rigorous fashion. An attempt was made to take all the problems in nuclear physics that have been solved semiquantitatively with the aid of simple models, reformulate them in more rigorous language, and express the results in terms of universal theoretical constants. (J.W.R.)

**19364** ON THE APPLICATION OF THE GROUP Sp(4) OR R(5) TO NUCLEAR STRUCTURE. Goshen, S. (Nuclear Research Center, Negev, Israel); Lipkin, H. J. pp 245-73 of Spectroscopic and Group Theoretical Methods in Physics. Block, F. (ed.). New York, John Wiley and Sons, Inc., 1968.

The representation of the Sp(2n) group for n = 2 is developed for the compact and noncompact cases and both are given physical interpretations. The noncompact version of Sp(4) relevant to the 2 dimensional harmonic oscillator has a Lie algebra isomorphic to the noncompact version R(3,2) of R(5). (J.W.R.)

**19365** EFFECT OF EXCHANGE AND THE PAULI PRINCIPLE ON NUCLEON–NUCLEUS SCATTERING. I. Friedman, William A.; Feshbach, Herman (Massachusetts Inst. of Tech., Cambridge). Contract AT(30-1)-2098. pp 231-44 of Spectroscopic and Group Theoretical Methods in Physics. Block, F. (ed.). New York, John Wiley and Sons, Inc., 1968.

The effects which arise in elastic and inelastic scattering due to the indistinguishableness of the incident and emergent particles from the target nucleons are discussed. A method is described for the explicit consideration of identical particle effects in the case of the N coupled channel problem. (J.W.R.)

**19366** DYNAMICAL THEORY OF NUCLEAR RESONANCES. Rosenfeld, Leon (Nordisk Institut for Teoretisk Atomfysik, Copenhagen). pp 203-30 of Spectroscopic and Group Theoretical Methods in Physics. Block, F. (ed.). New York, John Wiley and Sons, Inc., 1968.

The main features of the dynamical analysis of resonance effects in nuclear reactions are described. It is shown how the total Hamiltonian is separated into a model Hamiltonian and a residual interaction, and how the eigenfunctions of the total Hamiltonian are found. (J.W.R.)

**19367** STRONG ABSORPTION MODEL FOR ELASTIC SCATTERING OF $^3$He PARTICLES. Rahman, M. (Atomic Energy Centre, Dacca, Pakistan); Dutta Banik, N. C.; Sen Gupta, H. M. Nucl. Phys., A125: 449-62(1969).

The angular distributions of $^3$He particles elastically scattered from carbon, nitrogen, oxygen, magnesium, aluminum, argon and iodine were analyzed in terms of the strong absorption model of Frahn and Venter and the best-fit values of the parameters T, $\Delta$ and $\mu$ have been obtained. An overall satisfactory agreement was obtained except in light nuclei. The interaction radius, surface diffuseness, and the total reaction cross section were calculated from the parameter values. (auth)

**19368** DWBA ANALYSIS OF (p,d) REACTIONS ON LIGHT NUCLEI AT 156 MeV. Towner, I. S. (Oxford Univ.). Nucl. Phys., A126: 97-114(1969).

The experimental data of the previous paper were analyzed using the distorted-wave Born approximation (DWBA). Deuteron optical potentials are found by reanalyzing some early elastic deuteron scattering data at high energies. Various choices of prescriptions for the form factor of the transferred neutron are investigated, and it is concluded that a greater sensitivity to these form factors is obtained at lower energies than the 156 MeV of the present work. The spectroscopic factors obtained by normalizing the DWBA to experiment are in good agreement with the shell-model calculations of Cohen and Kurath. However these factors show systematic variations from the plane wave analysis given in the previous paper due to the strong Q-value dependence exhibited by the DWBA calculations. (auth)

**19369** POLARIZATION OF NUCLEI BY $\gamma$ RAYS. Pokazan'ev, V. G. Yadern. Fiz., 9: 32-9(Jan. 1969). (In Russian).

Angular momentum transfer from $\gamma$ radiation to a system of noninteracting nuclei in the ground state was studied by the density-matrix method. An equation of motion for the population of nuclear sublevels was obtained from which it follows that there exists a possibility of getting a predominant population of one of the ground-state sublevels in the nuclei exposed to polarized $\gamma$ rays. (auth)

**19370** DETERMINATION OF ISOSPIN TERM IN THE SHELL POTENTIAL FROM THE NUCLEON BINDING ENERGIES. Krasnov, L. V.; Litvin, V. F.; Lyutin, V. D. (Leningrad State Univ.). Yadern. Fiz., 9: 40-7(Jan. 1969). (In Russian).

Depth of the isospin term in the shell potential was determined from the measured binding energies of nucleons on the one-particle levels in various isotopes of the same element. The elements from Ca up to Sn and the levels of the average field $2p_{\frac{1}{2}}$, $2p_{\frac{3}{2}}$, $1g_{\frac{9}{2}}$, $2d_{\frac{5}{2}}$, $2d_{\frac{3}{2}}$, $3s_{\frac{1}{2}}$, $1h_{\frac{11}{2}}$, and $1g_{\frac{7}{2}}$ were considered. The mean value of the depth of the isospin term is about 170 MeV from the neutron binding energies and about 140 MeV from the proton binding energies. (auth)

**19371** CALCULATION OF SUBSEQUENT PARTICLE EMISSION FROM HIGHLY EXCITED NUCLEI WITH HIGH ANGULAR MOMENTUM. Il'inov, A. S.; Toneev, V. D. (Joint Inst. for Nuclear Research, Dubna, USSR). Yadern. Fiz., 9: 48-55(Jan. 1969). (In Russian).

The behavior of highly excited nuclei produced as a result of the interaction between heavy ions and target nuclei was investigated. The calculation was performed by means of the Monte Carlo method. A detailed comparison of various properties of the interaction with the experiments was carried out taking some nuclear reactions as an example. The influence of parameters of the model on these properties was investigated. (auth)

**19372** SINGLE-PARTICLE LEVELS OF FINITE DEFORMED POTENTIAL. Pashkevich, V. V.; Strutinskii, V. M. (Joint Inst. for Nuclear Research, Dubna, USSR). Yadern. Fiz., 9: 56-62(Jan. 1969). (In Russian).

A method for calculating the single-particle energy spectrum and the wave functions for a Hamiltonian with a finite axial-symmetrical potential with diffuse edge is presented. The wave functions are searched for as an expansion over eigenfunctions of the deformed harmonic oscillator. Special attention is paid to the most economic choice of the basis for each deformation and to the reasonable calculation of matrix elements aiming to achieve the high efficiency of the method. The energies of bound as well as quasi-stationary states are calculated. (auth)

**19373** QUADRANGLE GRAPH AND INELASTIC SCATTERING OF LOW-ENERGY (5 TO 10 MeV) PROTONS AND DEUTERONS ON SOME p-SHELL NUCLEI. Neudachin, V. G.; Magzumov, E. Zh.; Romanovskii, E. A. (Inst. of Nuclear Physics, Moscow). Yadern. Fiz., 9: 94-9(Jan. 1969). (In Russian).

Conditions are formulated for a target nucleus, under which the inelastic scattering of low-energy (5 to 10 MeV) protons (deuterons) is described by a quadrangle graph at small angles. An approximate method to calculate the reaction amplitudes for this mechanism is presented. Calculations were carried out for proton inelastic scattering on $^{9}$Be and for deuteron inelastic scattering on $^{10}$B. A number of experimental problems are proposed. (auth)

**19374** NUCLEAR WAVE FUNCTIONS FOR ARBITRARY NUMBER OF NUCLEONS: MATRIX ELEMENTS. Badalyan, A. M.; Simonov, Yu. A. (Inst. of Theoretical and Experimental Physics, Moscow). Yadern. Fiz., 9: 69-86(Jan. 1969). (In Russian).

Orthonormalization properties of harmonic functions, constructed previously for an arbitrary number of nucleons, were considered. A method was developed that makes it possible to calculate matrix elements of one- and two-particle operators. (auth)

**19375** SELF-CONSISTENT NUCLEAR SPECTROSCOPY WITH TWO-NUCLEON TRANSFER REACTIONS. Kolltveit, Kristofer (California Inst. of Tech., Pasadena). Nucl. Phys., A126: 115-28 (1969).

An attempt was made to calculate the wave functions of the lowest $J = 0^+$ states in both the target and the residual nucleus directly from two-particle transfer reactions. Due to serious limitations on the dimensions of the shell model subspace and partly due to the choice of test nuclei, the results are at best only in qualitative agreement with shell-model calculations. Some estimates were made on the accuracy of nuclear spectroscopy with two-particle as compared to one-particle transfer reactions; and it is shown that the greater uncertainties in the optical-model calculations for two-particle transfer reactions are compensated for by the sensitivity of the cross sections to the shell-model amplitudes. (auth)

**19376** PION REACTIONS WITH LIGHT NUCLEI AT THE 3–3 RESONANCE. Chivers, D. T.; Rimmer, E. M.; Allardyce, B. W.; Witcomb, R. C.; Domingo, J. J.; Tanner, N. W. (Oxford Univ.). Nucl. Phys., A126: 129-60(1969).

The reactions of positive and negative pions with light nuclei were studied over the energy range 80 to 280 MeV by detecting the residual radioactivity. Charge exchange, $(\pi^+,\pi^0)$, is shown to be closely related to the corresponding nucleon reaction, (p,n), but it is difficult to account for the ratio of the cross sections of $^{13}C(\pi^+,\pi^0)^{13}N$ and of $^{14}N(\pi^+,\pi^0)^{14}O$ in detail. Most of the reaction cross section of pions is made up by processes such as $^{12}C \xrightarrow{\pi} {}^{11}C$, i.e., single nucleon knockout. Previously this was accounted for quantitatively in terms of quasi-free scattering, which predicts a ratio of 3:1 for the $^{11}C$ production by $\pi^-$ and $\pi^+$ (influence of the 3-3 resonance of the $\pi$-nucleon interaction). The ratio observed is $1.0 \pm 0.1$ for $^{12}C \rightarrow {}^{11}C$, $^{14}N \rightarrow {}^{13}N$ and $^{16}O \rightarrow {}^{15}O$. The simplest explanation is that the activity is the result of roughly equal amounts of quasi-free scattering and inelastic scattering exciting the giant dipole resonance of the target nucleus. Alternatively, a more complicated interaction of pions with nucleon pairs could account for almost any ratio. Cross sections for 22 $\pi$ reactions at 180 MeV are presented together with excitation functions for 5 of these reactions. (auth)

**19377** IRREDUCIBLE TENSOR OPERATOR FORM FOR THREE-BODY POTENTIALS. Pask, Colin (Univ. of New South Wales, Kensington). Nucl. Phys., A126: 181-92(1969).

Certain three-body potentials are expressed in a form suitable for use in calculations involving $^{3}H$. This involves irreducible tensor operators for which useful properties are derived and discussed. Properties of the potentials are discussed. (auth)

**19378** EFFECTIVE-INTERACTION FORMULATION OF BOUND AND CONTINUUM SHELL-MODEL CALCULATIONS. McVoy, K. W.; Romo, W. J. (Argonne National Lab., Ill.). Nucl. Phys., A126: 161-80(1969).

The Bloch–Horwitz effective interaction, or reaction matrix, V(E), plays a central role in most of the current realistic shell-model calculations of bound-state nuclear spectra. Its relation to continuum shell-model calculations is less widely appreciated, however, and the purpose of the present review is to formulate the usual bound-state calculation in a manner which is readily generalized to describe scattering as well, in order to show that the analytic continuation of V(E) to continuum energies is just the effective or closed-channel interaction which appears in the reaction formalisms of MacDonald and Feshbach. Since the utility of the effective-interaction concept in practical calculations appears to depend on the convergence of its Born series, this convergence is discussed in terms of Weinberg eigenvalues, and its relation to the state dependence of V(E) is indicated. (auth)

**19379** MATHEMATICAL FILTER FOR THE ANALYSIS OF NARROW ELASTIC SCATTERING ANOMALIES. Bloch, R. (Univ., Zurich). Nucl. Instrum. Methods, 69: 170-2(Mar. 1969).

A method is described to unfold proton elastic scattering anomalies, distorted by finite beam energy resolution. The method makes use of the fact that the distortion of the capture yield is related to that of the scattering anomaly. (auth)

**19380** PHYSICAL MEANING OF THE NON-RELATIVISTIC CROSSED PARTIAL-WAVE EXPANSION. Cocho, G.; Mondragon, A. (Univ. Nacional Autonoma de Mexico, Mexico City). Nucl. Phys., A125: 417-24(1969).

The meaning of the parameters $\nu$ and $\mu$ which label the non-relativistic crossed partial-wave expansion is explored. It is shown that the values of these parameters may be related to a Wigner time delay for a cylindrical packet. (auth)

**19381** NON-RELATIVISTIC CROSSED PARTIAL-WAVE EXPANSION AND NUCLEON–NUCLEUS SCATTERING. Cocho, G. (Univ. de Mexico, Mexico City); Mondragon, A.; Colon-Vela, M. Nucl. Phys., A125: 425-39(1969).

The scattering of nucleons by nuclei is expanded in "crossed partial waves." This expansion is the nonrelativistic analogue of the Regge–Joos representation used in relativistic particle physics. It may be interpreted as a decomposition of the scattering amplitude into partial amplitudes, each one of these corresponding to the exchange of a set of pseudostates transforming irreducibly under the Galilei group, in complete analogy with the ordinary partial wave expansion in the direct channel. A small range of the expansion parameter $\nu$ gives the small curvature components of the cross section, making this expansion especially appropriate for the description of the energy averaged scattering amplitude. Explicit formulae are given for the elastic scattering of particles with arbitrary spin for the nonforward and forward scattering, where the little groups are E(3) and E(2), respectively.

In close analogy with the Regge poles and Regge trajectories which appear in relativistic high-energy scattering, the concept of Euclidian poles and trajectories is introduced. The formalism is applied to the scattering of nucleons by alpha particles. The parametrization of the scattering amplitude is made with two effective multipoles defined in the origin of the v plane. Assuming that the amplitude obeys unsubtracted dispersion relations in the energy for fixed momentum transfer we obtain a good fit for the differential cross section and polarization for values of the energy in the range from 66 to 312 MeV. (auth)

**19382** GROUP THEORY OF HARMONIC OSCILLATORS. V. THE HARMONIC OSCILLATOR SHELL MODEL. Kramer, P.; Moshinsky, M. (State Univ. of New York, Stony Brook). Nucl. Phys., A125: 321-38(1969).

In the present series of papers, the explicit construction of states for a system of n particles in a harmonic oscillator common potential is considered. These states were classified by the irreducible representations (IR) of the symmetry group of the harmonic oscillator, i.e., the unitary group of three dimensions $\mathcal{U}_3$ and its rotational subgroup $R_3$. Furthermore, they are also characterized by the IR of the chain of groups $U_n \supset S_n$ where the latter groups are respectively the unitary and symmetric group associated with the n particles. In this paper, it is shown that the shell structure of the n-particle states in a harmonic oscillator potential can be obtained when one characterizes further the states by the IR of a group $K_n$. This group is the semi-direct product of the group of n-dimensional diagonal unitary matrices $A_n$ and of the symmetric group, i.e., $K_n = A_n \wedge S_n$. Using these chains of groups, shell-model states are constructed in the harmonic oscillator potential, and the fractional parentage coefficients (fpc) in terms of the Wigner coefficients of the groups in the chain are obtained. An important result is that the fpc become much simpler when the IR of $\mathcal{U}_3$ are of one and two rows than when they have the most general form of three rows. Thus, for example, for particles in the 2d-1d shell of the harmonic oscillator, the fpc corresponding to a two-row IR of $U_3$ become a product of the familiar fpc in the p-shell tabulated by Jahn and a reduced Wigner coefficient of $\mathcal{U}_3$ in the $\mathcal{U}_3 \supset R_3$ chain, for which many programs and tables are available. The present analysis may be useful in the many cases of physical interest when one needs the fpc in a multishell state in the harmonic oscillator potential with the IR of $\mathcal{U}_3$ not exceeding two rows. (auth)

**19383** ROTATIONAL MOTION AND NON-ADIABATICITY IN THE GROUND STATE. Frauendorf, S.; Janssen, D.; Muenchow, L. (Central Inst. for Nuclear Research, Rossendorf, Ger.). Nucl. Phys., A125: 369-82(1969).

Rotational motion is described using an effective internal Hamiltonian, which is degenerate with respect to the angular momentum. The main point is a self-consistent calculation of the influence of motion on internal motion. As a result, moments of inertia are obtained for rare earth nuclei in good accordance with experiment. Further, for small deformations there appear essential differences to the usual description of deformed states. (auth)

**19384** EVAPORATION STEP IN SPALLATION REACTIONS. Rudstam, G. (Swedish Research Council, Studsvik, Sweden). Nucl. Phys., A126: 401-27(1969).

The Weisskopf evaporation theory was applied to a study of the evaporation chains originating from highly excited nuclei. The calculation is analytical and therefore not subject to the uncertainties of statistical nature adherent to Monte Carlo treatments of the same problem. An adjustment of the parameters of the evaporation formula leads to good agreement with experimental cross sections for products of complex spallation reactions. (auth)

**19385** POLARIZATION IN DEUTERON STRIPPING REACTIONS. Gubkin, I. A. (Leningrad State Univ.). Nucl. Phys., A126: 355-60(1969).

A formula for the polarization of protons in (d,p) $l_n = 0$ reactions, where spin-orbit distortion is present in the outgoing proton channel, was derived in the semiclassical approximation. It is similar to the formula for the polarization when unpolarized protons scatter elastically from the target nucleus. The formula thus obtained agrees well with experimental data. (auth)

**19386** ABSENCE OF $|T_z| = 1$ PAIRING CORRELATIONS IN THE INTRINSIC GROUND STATES OF 2s-1d SHELL NUCLEI. Sauer, P. U. (Univ., Muenster, Ger.); Faessler, Amand; Wolter, H. H.; Stingl, M. M. Nucl. Phys., A125: 257-66(1969).

The importance of pairing in the intrinsic ground states of doubly even 2s-1d shell nuclei was investigated. The nuclear many-body problem was solved following a restricted Hartree-Fock-Bogolyubov method which allows for p-p and n-n pairing only and for at most axially symmetric and reflection-invariant ground-state deformations. As nucleon-nucleon interaction, the semi-realistic Brink-Boeker force $B_1$ is employed which can not yield any single-particle spin-orbit splittings. The Coulomb force is included, and the center-of-mass motion is corrected for in the usual way. The ground state properties obtained are compared with the results of an ordinary Hartree-Fock procedure and turn out to be identical with them. There are no pairing correlations of the considered type in the ground states of 2s-1d shell nuclei. The calculated binding energies, rms radii, and quadrupole moments are reported. The resulting single-particle energies and self-consistent potentials are discussed. (auth)

**19387** VALIDITY OF THE HARTREE-BOGOLYUBOV THEORY IN AN EXACTLY SOLVABLE MODEL. Bleuler, K.; Friederich, A.; Schuette, D. (Institut fuer Theoretische Kernphysik, Bonn). Nucl. Phys., A126: 628-40(1969).

The structure and the validity of the Hartree-Bogolyubov (HB) theory are investigated within a special, exactly solvable model of the n-body problem, which was introduced previously and which contains only pairing and monopole forces. The HB theory is applied to this model in the variational form since there are convergence difficulties for the diagonalization procedure of solving the HB equation. For including the blocking effect the problems of even and odd numbers of particles are treated separately. For this model the HB equations yield solutions of essentially different type simultaneously (Hartree-Fock, BCS, mixed HB solutions). A comparison to the exact results shows that the properties of the energetically lowest solutions are satisfactory for ranges of model parameters where one of the two interaction types is overwhelming, whereas in the transition region there are large discrepancies (especially for the structure of the spectrum for the systems of an odd number of particles). The importance of the blocking effect is small and it can be taken into good account by introducing suitable constraints on the mean number of particles. (auth)

**19388** METHOD TO COMPUTE SOME MANY-BODY PHASE-SPACE INTEGRALS. Proriol, J. (Institut Univ. de Technologie, Montlucon, France). Nucl. Phys., A126: 689-95(1969).

Some difficulties connected with the evaluations of the limits in different integrals computed in a many-body phase-space integration are eliminated. These phase-space integrals are general and include dynamical matrix elements. (auth)

**19389** N-BODY FADDEEV EQUATIONS AND THE CLUSTER EXPANSION. Bierter, Willy (Univ. of California, Berkeley). Nucl. Phys., A126: 675-88(1969).

A set of integral equations of the Faddeev type is derived for the N-particle scattering amplitude. This Faddeev theory for the N-body scattering problem then provides a closed theory for the cluster coefficients of an arbitrary quantum gas, which is free of convergence difficulties encountered in former series expansions. (auth)

**19390** LIPPMANN-SCHWINGER EQUATION FOR NUCLEAR SCATTERING. Schuette, G. (Univ., Heidelberg). Nucl. Phys., A126: 513-28(1969).

The scattering of one particle by a target of A nucleons is treated in the frame of the shell model. The bound states of the complete Hamiltonian for A particles are expanded into antisymmetrized products of bound and unbound one-particle shell-model functions. From these exact target states a basis for the description of the scattering problem is constructed. As the elements of this basis we take all bound shell-model states of the (A + 1)-particle system and all antisymmetrized products of the exact bound states of the target with an unbound one-particle state. Because of the antisymmetrization, the elements of this basis are not orthogonal. Under suitable assumptions they can, however, be shown to be linearly independent. That is why a dual basis exists. This basis is constructed explicitly. With its help the Lippmann-Schwinger equation is derived. It is proved that the integral operator in this equation has finite Hilbert-Schmidt norm for complex energies. (auth)

**19391** THE NORMALISATION FACTOR IN (t,d) REACTIONS. Glover, R. N. (Atomic Weapons Research Establishment, Aldermaston, Eng.). Phys. Lett., 28B: 551-2(Feb. 3, 1969).

Data from (t,d) reactions are analyzed in a reasonably consistent manner and over the periodic table; a mean value of the normalization factor $N = 4.05 \pm 0.81$ is obtained. The agreement with theory is discussed. (auth)

**19392** BANDS OF CLUSTER STATES IN NUCLEI AT HIGH EXCITATION. Baz, A. I.; Manko, V. I. Phys. Lett., 28B: 541-3(Feb. 3, 1969).

Arguments are adduced to sustain the assumption that nuclei at high excitation energies should have systems of cluster levels, connected with some thresholds of two-body break-up. The main properties of such levels, which are consequences of their cluster structure, are discussed. (auth)

**19393** SINGLE-PARTICLE POTENTIALS AND THE STABILITY OF SUPERHEAVY NUCLEI. Musychka, Yu. A. (Joint Inst. for Nuclear Research, Dubna, USSR). Phys. Lett., 28B: 539-40(Feb. 3, 1969).

Using various schemes of single-particle levels, the fission barriers for a number of superheavy nuclei were calculated. The results of calculation confirm the conclusion about the existence of the superheavy nuclei region with a relative stability against spontaneous fission. (auth)

**19394** ARE THE ROTATIONAL BANDS ASSIGNED CORRECTLY IN THE NUCLEAR $SU_3$ MODEL? Biedenharn, L. C. (California Inst. of Tech., Pasadena). Phys. Lett., 28B: 537-8 (Feb. 3, 1969).

The assignment of rotational bands in $SU_3$ is discussed for the self-conjugate representations, [2q q 0], for which the existence of a formal parity ("s-parity") implies a unique solution. (auth)

**19395** REPULSIVE NUCLEUS–NUCLEUS FORCES AND STATISTICAL MODEL OF FISSION OF HEAVY NUCLEI. Facchini, U.; Gadioli-Erba, E.; Saetta-Menichella, E. (CISE, Milan, Univ., Milan). Phys. Lett., 28B: 534-6(Feb. 3, 1969).

There are new ideas on the interpretation of a fission model used for preceding calculations. The Strutinsky model for nuclear deformation supports the assumption of statistical equilibrium before scission. Sharp barriers acting between the two fragments are explained through nucleus-nucleus rearrangement forces. (auth)

**19396** QUASI-ELASTIC ELECTRON SCATTERING ON NUCLEI WITH KNOCKOUT OF COMPLEX PARTICLES. II. Balashov, V. V.; Meboniya, D. V. (Moscow State Univ. Tbilisi State Univ., USSR). Izv. Akad. Nauk Arm. SSR, Ser. Fiz., 3: 167-79 (1968). (In Russian).

An extended analysis of the possibilities of using reactions of the type (e,e'x) for studies of the structure of light nuclei is presented. It is shown that experiments of the type (e,e'd) can give valuable information on the probability of production and the motion of clusters in nuclei. (D.C.W.)

# REACTOR TECHNOLOGY

## Commercial Power Reactors

*Refer also to abstract 17667.*

**19397** (AEC-tr-7032) 50-MWe DODEWAARD NUCLEAR POWER PLANT. Annual Report, 1967. (Gemeenschappelijke Kernenergiecentrale Nederland N. V., Dodewaard. Samenwerkende Electriciteits-Productiebedrijven, N. V., Arnhem (Netherlands)). Translation of report EUR-4069. 157p. Dep. CFSTI.

Systems of the Oodewaard Power Reactor that were assembled during 1967 include: cooling water system; containment system; water processing systems; ventilation system; pressurized air equipment; hydraulic system; and various servicing devices. Major components that were fabricated during 1967 include: the reactor vessel; the generator; the turbine; the heat exchangers; the feedwater pumps; and the control rod and flux monitoring pipes. The 150 kV power system was completely installed. Fabrication of the $UO_2$ pellets was completed during 1967. (auth)

**19398** (AEC-tr-7033) KERNKRAFTWERK GUNDREMMINGEN (KRB) ANNUAL REPORT FOR 1967. (Kernkraftwerk RWE-Bayernwerk G.m.b.H., Gundremmingen (West Germany)). Translated from a German report. 57p. Dep. CFSTI.

Operations in the Gundremmingen Power Reactor during 1967 are described. A review of plant operation, individual component performance, and maintenance is presented. Licenses granted during 1967 are listed. Radiation monitoring and water chemistry data are presented. Plant costs and operating costs are itemized. (D.C.C.)

**19399** (APDA-CFE-26) COMPILATION OF CURRENT TECHNICAL EXPERIENCE AT ENRICO FERMI ATOMIC POWER PLANT, OCTOBER 1968. Costello, R. H. (Atomic Power Development Associates, Inc., Detroit, Mich. Power Reactor Development Co., Detroit, Mich. Detroit Edison Co., Mich.). Jan. 1969. Contract AT(11-1)-865. 40p. Dep. CFSTI.

The remote-handling and remote-viewing devices for removing the Zr segments are described. The mockup testing of the remote-handling and remote-viewing devices is discussed. Reactor plant operations and maintenance during October 1968 are described. Results of steam generator tests are included. (D.C.C.)

**19400** (BNWL-936(Vol.2)) POWER REACTOR DESIGNS. AN ANNOTATED BIBLIOGRAPHY. VOLUME 2. SECTIONS FD-JF, INDEX. Appleby, E. R. (comp.) (Battelle-Northwest, Richland, Wash. Pacific Northwest Lab.). Jan. 1969. Contract AT(45-1)-1830. 302p. Dep. CFSTI.

An annotated bibliography on foreign and domestic power reactors is presented. The reactors are included in the following headings: liquid metal-cooled reactors; organic-cooled reactors; pressurized-water reactors; steam-cooled reactors; and nuclear auxiliary power systems. (D.C.C.)

**19401** (DLCS-5000468) SHIPPINGPORT ATOMIC POWER STATION FOURTH QUARTERLY OPERATING REPORT, 1968. (Duquesne Light Co., Shippingport, Pa. Power Stations Dept.). Contract AT(11-1)-292. 20p. Dep. CFSTI.

Operations during October to December 1968 are described. Topics discussed include: operations; station performance; chemistry; refueling program; maintenance; and test program. (D.C.C.)

**19402** (DOCKET-50133-2) [HUMBOLDT BAY POWER PLANT, UNIT NO. 3]. Division of Licensing and Regulation Report to Advisory Committee on Reactor Safeguards. (Pacific Gas and Electric Co., San Francisco, Calif.). Aug. 24, 1959. 11p. Dep. CFSTI.

The complete safety evaluation of the Humboldt Bay Power Reactor by the USAEC Division of Reactor Licensing is included. All major systems are discussed; reactor design is considered at length. The integrity of the containment system is evaluated. (M.L.S.)

**19403** (DOCKET-50171-1) PEACH BOTTOM ATOMIC POWER STATION, [UNIT 1]. [Preliminary Safety Analysis Report], Parts A and B. (Philadelphia Electric Co., Pa.). Aug. 7, 1961. 870p. Dep. CFSTI.

The license application for the Peach Bottom Power Reactor, Unit 1 is given. Names and addresses of principal officers of the Philadelphia Electric Company, owners of Peach Bottom, are listed; the contract between the USAEC, Philadelphia Electric, and the High Temperature Development Associates, Inc., is included. The Philadelphia Electric 1960 Annual Report is given; technical qualifications of contractors are listed. Design and safety analysis information for Peach Bottom, Unit 1 is given on the following broad topics: Nuclear Steam Supply System; Conventional Plant; Containment; Plant Operation; Radioactive Effluents; and Plant Safety Analysis. Fission product and radioactivity inventories are tabulated. Core heatup following loss of coolant is calculated; data and results of calculations are shown graphically. Steam generator tube ruptures are analysed. A brief site description is given; meteorologic, hydrologic and geologic data and characteristics are, then, detailed. (M.L.S.)

**19404** (DOCKET-50171-2) PEACH BOTTOM ATOMIC POWER STATION. Final Hazards Summary Report, Part C, Vol. 1. (Philadelphia Electric Co., Pa.). Mar. 3, 1964. 257p. Dep. CFSTI.

Detailed site and environmental information on Peach Bottom Power Reactor, Unit 1 is given. A general site description is presented; meteorologic, hydrologic, and geologic information is, then, detailed. (M.L.S.)

**19405** (DOCKET-50171-3) PEACH BOTTOM ATOMIC POWER STATION. Final Hazards Summary Report, Part C, Vol. 2. (Philadelphia Electric Co., Pa.). Mar. 3, 1964. 342p. Dep. CFSTI.

Information on Peach Bottom Power Reactor, Unit 1 is given on the following broad topics: Introduction and Summary and Nuclear Steam Supply System (NSSS). Included under the NSSS are core design, component design, fission product control and helium purification, cooling system, helium handling and storage, after-heat removal and emergency cooling systems, instrumentation and control systems, fuel handling system, and shielding. (M.L.S.)

**19406** (DOCKET-50171-4) PEACH BOTTOM ATOMIC POWER STATION. Final Hazards Summary Report, Part C, Vol. 3. (Philadelphia Electric Co., Pa.). Mar. 3, 1964. 194p. Dep. CFSTI.

Information on the Peach Bottom Power Reactor, Unit 1 is given on the following broad topics: Conventional Plant and Services; Containment; Plant Operation; Radioactive Effluents; and Plant Safety Analysis. (M.L.S.)

**19407** (DOCKET-50171-5) PEACH BOTTOM ATOMIC POWER STATION. Final Hazards Summary Report, Part C, Vol. 4. (Philadelphia Electric Co., Pa.). Mar. 3, 1964. 271p. Dep. CFSTI.

Complete engineering drawings are given for the Peach Bottom Power Reactor, Unit 1. Drawings are included for: Introduction and Summary; Nuclear Steam Supply System; Conventional Plant and Services; Containment; Plant Operation; Radioactive Effluents; and Plant Safety Analysis. (M.L.S.)

**19408** (DOCKET-50171-7) PEACH BOTTOM ATOMIC POWER STATION. Final Hazards Summary Report, Part C, Vol. 5. (Philadelphia Electric Co., Pa.). Aug. 11, 1964. 264p. Dep. CFSTI.

The design and fabrication of the Peach Bottom Power Reactor, Unit 1 pressure vessel and steam generators are detailed. Stress analyses techniques are described; calculational results are tabulated. The quality assurance programs are outlined. The radiation damage surveillance program for the pressure vessel is given. Design parameters and construction materials are listed for the steam generators. Complete design drawings and specifications for the pressure vessel and steam generators are included. (M.L.S.)

**19409** (DOCKET-50219-16) OYSTER CREEK NUCLEAR POWER PLANT, UNIT NO. 1. [Facility Description and Safety Analysis Report], App. A. (Jersey Central Power and Light Co., Morristown, N. J.). Dec. 23, 1968. 133p. Dep. CFSTI.

Complete Technical Specifications and design bases for Oyster Creek Power Reactor, Unit 1 are included. Definitions are listed; safety limits and limiting safety system settings, limiting conditions for operation, surveillance requirements, design features, and administrative controls. (M.L.S.)

**19410** (DOCKET-50220-18) NINE MILE POINT NUCLEAR STATION. Final Safety Analysis Report, Amendment 6, Suppl. 2, Exhibit D-4. (Niagara Mohawk Power Corp., Syracuse, N. Y.). Oct. 1968. 228p. Dep. CFSTI.

Answers to USAEC, Division of Reactor Licensing questions on Nine Mile Point Power Reactor are included on the following broad topics: General; Structures; Reactor; Containment; Reactor Auxiliary and Emergency Systems; and Safety Analysis. Revised and supplemental material is included, also. (M.L.S.)

**19411** (DOCKET-50220-19) NINE MILE POINT NUCLEAR STATION. Final Safety Analysis Report, Amendment 7, Suppl. 3, Exhibit D-5. (Niagara Mohawk Power Corp., Syracuse, N. Y.). Oct. 1968. 80p. Dep. CFSTI.

Design modifications to the control rod drive hydraulic line penetrations to the Nine Mile Point Power Reactor primary containment vessel are described. Plans for the cleaning and hydrostatic testing of the pressure vessel are outlined. Inspection of the stub tubes is detailed; results of dye penetrant, metallographic, and ultrasonic inspections are described. The weld-defect $\frac{3}{4}$-inch criterion is described; weld repair diagrams are shown. The complete stress analysis report for weld repairs on control rod drive penetrations is included. (M.L.S.)

**19412** (DOCKET-50220-20) NINE MILE POINT NUCLEAR STATION. Final Safety Analysis Report, Amendment 8, Suppl. 4, Exhibit D-6. (Niagara Mohawk Power Corp., Syracuse, N. Y.). Nov. 1968. 28p. Dep. CFSTI.

Design of electrical cable run trays for Nine Mile Point Power Reactor is described; this design and the electrical penetrations of the containment are evaluated. Consequences of complete loss of station air and/or vital instrument air are assessed for post-shutdown from full power and post accident conditions. Maximum stresses for the membrane and plate of the pressure suppression area are tabulated. Drywell shear resistance capability and support skirt junction stresses are given. Results of a reactor support structure thermal analysis are included. (M.L.S.)

**19413** (DOCKET-50220-21) NINE MILE POINT NUCLEAR STATION. Final Safety Analysis Report, Amendment 10, Suppl. 5, Exhibit D-7. (Niagara Mohawk Power Corp., Syracuse, N. Y.). Jan. 1969. 179p. Dep. CFSTI.

Feedwater and emergency condenser isolation valve ruptures in the Nine Mile Point Power Reactor are analysed in detail; data are shown graphically. The net positive suction head (NPSH) available to core and containment spray pumps is evaluated; suction temperature limits, head capacity, and system resistance for the pumps are shown graphically. Primary system leak rates are discussed; revised values are tabulated. The in-service inspection program of the primary system is described; the proposed inspection schedule is given. Additional detailed information on the core cooling system is presented; included are: safety objectives and design bases, a tabular summary of the operating modes available, pump summary, and a complete safety analysis of core cooling systems which describes, in detail, each analytical model used. Appendices include: description of core cooling tests and results, rod perforation tests, heat transfer during blowdown, hydrostatic testing of the reactor system and post-hydro inspection, description of radiation monitors with isolation function, a list of design modifications, test frequencies for instrumentation and equipment, calculational basis for containment initial conditions, and reactor building filtration. (M.L.S.)

**19414** (DOCKET-50220-22) NINE MILE POINT NUCLEAR STATION. Final Safety Analysis Report, Amendment 11, Suppl. 6, Exhibit D-8. (Niagara Mohawk Power Corp., Syracuse, N. Y.). Mar. 1969. 103p. Dep. CFSTI.

Results of post-hydro testing of control rod drive stub tube field welds for the Nine Mile Point Power Reactor are given. Data and reasoning supporting no clad overlay on core and internals are detailed; radiation histories are cited for Dresden 1 Big Rock Point, Humboldt Bay, SENN, KRB, and JPDR. The preoperational test program is outlined; the startup tests are listed. Emergency procedures are detailed for: evacuation, fire fighting, rescue, and contaminated injury. (M.L.S.)

**19415** (DOCKET-50220-23) [NINE MILE POINT NUCLEAR STATION]. [Final Safety Analysis Report], Amendment 9, Exhibit C-2. (Niagara Mohawk Power Corp., Syracuse, N. Y.). Jan. 21, 1969. 32p. Dep. CFSTI.

Financial data on the Niagara Mohawk Power Corporation, owners of Nine Mile Point Power Reactor, are given. Annual estimated operating costs are listed. The complete 1967 Annual Report for the Niagara Mohawk Power Corporation is included. (M.L.S.)

**19416** (DOCKET-50245-9) MILLSTONE NUCLEAR POWER STATION, [UNIT 1]. Final Safety Analysis Report, Amendment 12. (Connecticut Light and Power Co., Hartford. Hartford Electric Light Co., Conn. Western Massachusetts Electric Co., Greenfield. Millstone Point Co., Wethersfield, Conn.). Feb. 26, 1969. 78p. Dep. CFSTI.

Revised or additional information is included on all sections of the Final Safety Analysis Report for Millstone Point Power Reactor, Unit 1. (M.L.S.)

**19417** (DOCKET-50245-10) MILLSTONE NUCLEAR POWER STATION, UNIT 1. [Final Safety Analysis Report], Amendment 13, App. D. (Connecticut Light and Power Co., Hartford. Hartford Electric Light Co., Conn. Western Massachusetts Electric Co., Greenfield. Millstone Point Co., Wethersfield, Conn.). Mar. 10, 1969. 162p. Dep. CFSTI.

The complete containment report for the Millstone Point Power Reactor, Unit 1 is included. Bases for the containment design are given; containment system design is detailed. Containment shell fabrication, erection, and testing is described; engineering and design drawings are included. Fabrication and installation of penetrations and nozzles are detailed. The report on the initial overload and leakage rate tests is included. (M.L.S.)

**19418** (DOCKET-50245-11) MILLSTONE NUCLEAR POWER STATION, UNIT 1. [Final Safety Analysis Report], Amendment 13, App. E. (Connecticut Light and Power Co., Hartford. Hartford Electric Light Co., Conn. Western Massachusetts Electric Co., Greenfield. Millstone Point Co., Wethersfield, Conn.). Mar. 10, 1969. 207p. Dep. CFSTI.

The complete reactor pressure vessel design report for Millstone Point Power Reactor, Unit 1 is given. A stress analysis is summarized; purchase specification sheets are included. The inspection report is given; the furnace log is included in this report. The fabrication test program is detailed; results of tensile tests on pressure vessel steel specimens are tabulated. A seismic analysis of the reactor pressure vessel is detailed. (M.L.S.)

**19419** (DOCKET-50255-14) PALISADES PLANT. Final Safety Analysis Report, Amendment 9, Vol. 1. (Consumers Power Co., Jackson, Mich.). Nov. 1, 1968. 417p. Dep. CFSTI.

Information on the Palisades Power Reactor is given on the following broad topics: Introduction and Summary; Site and Environment; Reactor; Primary Coolant System; Structures; and Engineered Safeguards Systems. (M.L.S.)

**19420** (DOCKET-50263-19) MONTICELLO NUCLEAR GENERATING PLANT, [MONTICELLO, MINNESOTA], UNIT NO. 1. Containment Vessel Design Summary. Final Safety Analysis Report, Amendment 12. (Northern States Power Co., Minneapolis, Minn.). Mar. 7, 1969. 77p. Dep. CFSTI.

The containment vessel design for Monticello Power Reactor, Unit 1 is summarized. Containment system criteria and design are discussed; applicable codes and materials are described. Design pressures and temperatures, design loads, and load combinations are listed. Complete leakage and overload test procedures and results are given; leakage rate test data are tabulated. Code certifications forms and drawings are included. (M.L.S.)

**19421** (DOCKET-50269-1) OCONEE NUCLEAR STATION, UNITS 1 AND 2. Preliminary Safety Analysis Report, Vol. 1. (Duke Power Co., Charlotte, N. C.). Dec. 1, 1966. 478p. (DOCKET-50270-1). Dep. CFSTI.

Information on Oconee Power Reactor, Units 1 and 2 is given under the following broad topics: Introduction and Summary; Site and Environment; Reactor; Reactor Coolant System; Containment System; Engineered Safeguards; Instrumentation and Control; Electrical Systems; Auxiliary and Emergency Systems; and Steam and Power Conversion Systems. (M.L.S.)

**19422** (DOCKET-50269-2) OCONEE NUCLEAR STATION, UNITS 1 AND 2. Preliminary Safety Analysis Report, Vol. 2. (Duke Power Co., Charlotte, N. C.). Dec. 1, 1966. 411p. (DOCKET-50270-2). Dep. CFSTI.

Information on Oconee Power Reactor, Units 1 and 2 is given on the following broad topics: Radioactive Wastes and Radiation Protection; Conduct of Operations; Initial Tests and Operation; and Safety Analysis. Appendices include: technical qualifications of personnel associated with Oconee 1 and 2, subsurface and foundations, seismology and meteorology, groundwater hydrology, field permeability tests, geology, a complete description of the Babcock and Wilcox once-through steam generator, structural design bases, the design program and criteria for the reactor building, quality control programs, liner plate specifications, and reactor building instrumentation. (M.L.S.)

**19423** (DOCKET-50269-3) [OCONEE NUCLEAR STATION, UNITS 1 AND 2]. Preliminary Safety Analysis Report, Amendment 1. (Duke Power Co., Charlotte, N. C.). Apr. 4, 1967. 265p. (DOCKET-50270-3). Dep. CFSTI.

Specific ASME Code vessel classifications for all Oconee Power Reactor, Units 1 and 2, cooling system components are listed. Calculations to determine the possible presence of axial xenon oscillations in the Oconee cores are described; methods for control of possible oscillations are discussed. Water intake locations for communities surrounding the Oconee site are shown; intake volumes are tabulated for each community. Methods used to cal-

culate core void fractions are detailed. Requirements for cooling the water recirculated from the reactor building sump to the reactor building spray are described. The requirements for net positive suction head (NPSH) for emergency recirculation pumps are given. The amount of time available to isolate the service water in case of a coolant loss accident is calculated. Parameters used for seismic design evaluation are given. Seismic stability of the Keowee Dam, near the Oconee site, is evaluated in detail; data are shown graphically and tabularly. Construction procedures and standards are considered. Instrumentation for monitoring around the equipment hatch of the containment vessel during proof testing is described; instruments and locations are shown schematically. (M.L.S.)

**19424** (DOCKET-50269-4) [OCONEE NUCLEAR STATION, UNITS 1, 2, AND 3]. Preliminary Safety Analysis Report, Amendment 3. (Duke Power Co., Charlotte, N. C.). Apr. 29, 1967. 47p. (DOCKET-50270-4; DOCKET-50287-1). Dep. CFSTI.

The addition of Unit 3 to the already planned Oconee Power Reactor, Units 1 and 2, is recorded. Estimated costs for the station, including the three units, are tabulated. Revised pages to the original Preliminary Safety Analysis Report (PSAR) are included. (M.L.S.)

**19425** (DOCKET-50269-5) [OCONEE NUCLEAR STATION, UNITS 1, 2, AND 3]. Preliminary Safety Analysis Report, Amendment 4. (Duke Power Co., Charlotte, N. C.). May 29, 1967. 32p. (DOCKET-50270-5; DOCKET-50287-2). Dep. CFSTI.

Time periods required for various modes of emergency power supply and shutdown cooling for Oconee Power Reactor, Units 1, 2, and 3, are tabulated. Foundation investigations for the dams near the Oconee site are discussed. Possibilities of reconcentration of liquid discharges downstream from the Oconee site are evaluated. DNB ratios for nominal and worst hot channels are tabulated; cell dimensions are shown for the worst hot channel case. Check valve leakage in the core flooding system is discussed. Emergency Core Cooling System (ECCS) operation-induced shock effects on the reactor vessel and thermal shield near the end of the design-life are evaluated. Core reactivity effects after a steam line break with generator tube ruptures are analyzed. (M.L.S.)

**19426** (DOCKET-50298-9) COOPER NUCLEAR STATION. Preliminary Safety Analysis Report, Vol. 1. (Consumers Public Power District, Columbus, Nebr.). July 27, 1967. 301p. Dep. CFSTI.

Information on Cooper Power Reactor is given on the following broad topics: Introduction and Summary; Site; Reactor Core and Internals; Reactor Coolant System; Containment Systems; and Additional Engineered Safeguards. (M.L.S.)

**19427** (DOCKET-50298-10) COOPER NUCLEAR STATION. Preliminary Safety Analysis Report, Vol. 2. (Consumers Public Power District, Columbus, Nebr.). July 27, 1967. 340p. Dep. CFSTI.

Information on Cooper Power Reactor is given on the following broad topics: Control and Instrumentation; Electrical Power Supply Systems; Radioactive Waste Systems; Auxiliary Systems; Power Conversion System; Structures and Shielding; Conduct of Operation; and Safety Analyses. (M.L.S.)

**19428** (DOCKET-50298-11) COOPER NUCLEAR STATION. Preliminary Safety Analysis Report, Vol. 3. (Consumers Public Power District, Columbus, Nebr.). July 27, 1967. 252p. Dep. CFSTI.

The complete geology, seismology, subsurface investigations, and foundation recommendations for the Cooper Power Reactor site are included. Data are given in tabular and graphic form. A soil liquefaction analysis is detailed; foundation analyses and recommended schemes are described. Seismologic design response spectra are discussed. Some construction methods are described. (M.L.S.)

**19429** (DOCKET-50319-8) BELL STATION. [Preliminary Safety Analysis Report], Amendment 4. (New York State Electric and Gas Corp., Binghamton). Mar. 5, 1969. 39p. Dep. CFSTI.

Safety significance of postulated post-accident radiolysis products in the Bell Power Reactor is discussed; available information on radiolysis is summarized. The overall effort to define any potential problem caused by radiolysis is outlined. Supplemental information is included on: the Local Power Range Monitoring (LRPM) subsystem, loss of station power, the spent fuel cooling and demineralizer system, transmittal of seismic shear forces through the containment structure, and the overall quality assurance program. (M.L.S.)

**19430** (DOCKET-50321-7) EDWIN I. HATCH NUCLEAR PLANT, UNIT 1. Preliminary Safety Analysis Report, Amendment 3, Vol. 5. (Georgia Power Co., Atlanta). Mar. 10, 1969. 230p. Dep. CFSTI.

The quality assurance program for the Edwin I. Hatch Power Reactor, Unit 1 is detailed. Penetrations are tabulated for the secondary and primary-secondary containment structures. The area radiation monitoring system is described; liquid radwaste system typical release concentrations are tabulated. Piezometer readings of water table levels are listed; soil tests are discussed; soil classification data are tabulated. Generalized geologic sections and test boring records are included; soil liquefaction data are shown graphically. Effects of design changes on thermal margins are discussed. Methods to be used for brittle fracture prevention in the primary system are discussed. Boron requirements for the standby liquid control system are shown graphically. Scram set-points for the reactor protective system are discussed. The condensing mode of operation of the reactor core isolation cooling system is described. Design bases and performance requirements for the engineered safety features are discussed. Design bases for the secondary containment and standby gas treatment system are detailed; characteristics of both systems are shown graphically. (M.L.S.)

**19431** (DOCKET-50324-9) BRUNSWICK STEAM ELECTRIC PLANT, UNITS 1 AND 2. Preliminary Safety Analysis Report, Amendment 6, Suppl. 4. (Carolina Power and Light Co., Raleigh, N. C.). Mar. 12, 1969. 252p. (DOCKET-50325-9). Dep. CFSTI.

The analytical model, analysis method, and uncertainties associated with prediction of the maximum fast neutron fluence at the inner surface of the pressure vessel for the Brunswick Power Reactor, Units 1 and 2, are described; fast neutron fluence >1 MeV is shown as a function of radial distance from core $\ell$. Loading conditions and safety margins for reactor core and internals are listed. Analytical and experimental work on the radiolytic decomposition of water is summarized. The independent and redundant design features of the Emergency Core Cooling System (ECCS) are discussed; single failure accommodation without loss of function is evaluated. Pressure is shown as a function of time for the containment system suppression chamber and dry well; results of Bodega Bay and Humboldt Bay pressure suppression tests are tabulated. Effects of blowdown forces on primary system components are considered. Design criteria classification for the fire protection system is discussed. Data and calculations for determining low tide and storm flood elevations are included. Design bases for primary containment liquid leak rate detection are given; alarm set-points are identified. The analytical procedures used for determining seismic loadings of the containment structure are given; effects of soil pressure on buried structures, transmittal of tangential shear, and axisymmetrical loadings are considered. Detailed information on the control rod position indicator system is given. The off-gas holdup system is described; fission product inventories are tabulated. Adequacy of the design bases and performance requirements of the engineered safety features are evaluated. (M.L.S.)

**19432** (DOCKET-50336-1) MILLSTONE NUCLEAR POWER STATION, UNIT 2. Preliminary Safety Analysis Report, Vol. 1. (Connecticut Light and Power Co., Hartford. Hartford Electric Light Co., Conn. Western Massachusetts Electric Co., Greenfield. Millstone Point Co., Wethersfield, Conn.). Feb. 28, 1969. 411p. Dep. CFSTI.

Information on Millstone Point Power Reactor, Unit 2 is given on the following broad topics: Introduction and Summary; Site and Environment; Reactor; Reactor Coolant System; Containment; Engineered Safeguards; Instrumentation and Controls; Electrical Systems; Auxiliary Systems; and Steam and Power Conversion Systems. (M.L.S.)

**19433** (DOCKET-50336-2) MILLSTONE NUCLEAR POWER STATION, UNIT 2. Preliminary Safety Analysis Report, Vol. 2. (Connecticut Light and Power Co., Hartford. Hartford Electric Light Co., Conn. Western Massachusetts Electric Co., Greenfield. Millstone Point Co., Wethersfield, Conn.). Feb. 28, 1969. 328p. Dep. CFSTI.

Information on Millstone Point Power Reactor, Unit 2 is given on the following broad topics: Radioactive Waste and Radiation Protection; Conduct of Operations; Initial Tests and Operations; and Safety Analyses. Proposed Technical Specifications are outlined. Appendices include: qualifications of contractors; design comparison with the 70 General Design Criteria; detailed meteorologic, geologic, hydrologic, and seismologic data for the Millstone Point Site; seismic design bases for structures and systems; rebar splicing procedures; justification for load factors and load combinations used in design equations for the contain-

ment structure; description of the finite element method used in containment structural analyses; quality control procedures for field welding of liner plate; description of the instrumentation for the prestressed concrete containment structure; and analysis of liner plate stability. (M.L.S.)

**19434** (DOCKET-50336-3) MILLSTONE NUCLEAR POWER STATION, WATERFORD, CONNECTICUT, UNIT NO. 2. LICENSE APPLICATION. (Connecticut Light and Power Co., Hartford. Hartford Electric Light Co., Conn. Western Massachusetts Electric Co., Greenfield. Millstone Point Co., Wethersfield, Conn.). Mar. 1969. 77p. Dep. CFSTI.

The license application for Millstone Point Power Reactor, Unit 2 is included. Names and addresses of directors and principal officers of the applicant corporations are listed; financial qualifications are tabulated for each company. Bond-issuance information is included. (M.L.S.)

**19435** (DOCKET-50338-1) NORTH ANNA POWER STATION, [UNITS 1 AND 2], LOUISA COUNTY, VIRGINIA. Site Environmental Studies. (Dames and Moore, New York). Jan. 13, 1969. 137p. (DOCKET-50339-1). Dep. CFSTI.

For Virginia Electric and Power Co., Richmond.

Detailed site environmental studies for the site for the North Anna Power Reactor, Units 1 and 2, are included. Field explorations are described; laboratory tests are detailed. Geologic, hydrologic, and seismologic data are analyzed; data and results are presented in graphic and tabular form. (M.L.S.)

**19436** (DOCKET-50338-2) NORTH ANNA [POWER STATION], UNITS 1 AND 2. Proposed Preliminary Technical Specifications. (Virginia Electric and Power Co., Richmond). Jan. 1, 1969. 154p. (DOCKET-50339-2). Dep. CFSTI.

The proposed preliminary Technical Specifications for the North Anna Power Reactor, Units 1 and 2, are included. Safety limits and limiting safety system settings are described; limiting conditions for operation are specified. Surveillance requirements are outlined; design features are described. Administrative controls are listed. (M.L.S.)

**19437** (DOCKET-50338-3) NORTH ANNA POWER STATION, UNITS 1 AND 2. Preliminary Safety Analysis Report, Part B, Vol. 1. (Virginia Electric and Power Co., Richmond). Mar. 21, 1969. 417p. (DOCKET-50339-3). Dep. CFSTI.

Information on the North Anna Power Reactor, Units 1 and 2, is given on the following broad topics: Introduction and Summary; Site; and Reactor. (M.L.S.)

**19438** (DOCKET-50338-4) NORTH ANNA POWER STATION, UNITS 1 AND 2. Preliminary Safety Analysis Report, Part B, Vol. 2. (Virginia Electric and Power Co., Richmond). Mar. 21, 1969. 455p. (DOCKET-50339-4). Dep. CFSTI.

Information on North Anna Power Reactor, Units 1 and 2, is given on the following broad topics: Reactor Coolant System; Containment Systems; Engineered Safeguards; and Instrumentation and Control. (M.L.S.)

**19439** (DOCKET-50338-5) NORTH ANNA POWER STATION, UNITS 1 AND 2. Preliminary Safety Analysis Report, Part B, Vol. 3. (Virginia Electric and Power Co., Richmond). Mar. 21, 1969. 379p. (DOCKET-50339-5). Dep. CFSTI.

Information on North Anna Power Reactor, Units 1 and 2, is given on the following broad topics: Electrical Systems; Auxiliary and Emergency Systems; Steam and Power Conversion Systems; Radioactive Wastes and Radiation Protection; Conduct of Operations; and Initial Tests and Operations. (M.L.S.)

**19440** (DOCKET-50338-6) NORTH ANNA POWER STATION, UNITS 1 AND 2. Preliminary Safety Analysis Report, Part B, Vol. 4. (Virginia Electric and Power Co., Richmond). Mar. 21, 1969. 452p. (DOCKET-50339-6). Dep. CFSTI.

Information on North Anna Power Reactor, Units 1 and 2, is given on the following broad topics: Safety Analysis; and Structures and Construction, including structural design criteria, quality assurance programs, materials, construction procedures and practices, and specific structural designs. The seismic design for the nuclear steam supply system is detailed. (M.L.S.)

**19441** (NYO-3853-1) COMPETITION IN THE NUCLEAR POWER SUPPLY INDUSTRY. (Little (Arthur D.) Inc., [Cambridge, Mass.]). Dec. 1968. Contract AT(30-1)-3853. 430p. GPO $4.50.

A study of the industry that supplies nuclear-related goods and services to the utilities is presented. The study includes five subjects: product and market definition; market structure; trends in the structure; market performance; and innovation and progressiveness. (D.C.C.)

**19442** (ORO-665, pp 31-71) PROJECTION OF NUCLEAR POWER NEEDS. Vanstrum, Paul R. (Union Carbide Corp., Oak Ridge, Tenn. Nuclear Div.).

A review of power reactor development in the U. S. is presented. A graphical plot of predicted U. S. power reactors and their total MW(e) output is included for 1969 to 1977. A graphical plot of predicted worldwide power reactors using U. S. Enrichment Service is included for 1968 to 1975. Cost comparisons for nuclear- and fossil-fueled plants are discussed which include: capital investments; fuel cycle costs; operation and maintenance costs; annual capital charges; plant utilization or load factor; and qualitative effects of cost variables. An analysis of U. S. U reserves is presented. The effects of breeder reactors on nuclear power generation are described. 20 references. (D.C.C.)

**19443** (ORO-665, pp 175-83) ACQUIRING AND OPERATING A NUCLEAR POWER PLANT. Webster, William (Yankee Atomic Electric Co., Boston, Mass.).

Problems are discussed concerning power reactor development, the reliability of nuclear plant performance, and International safeguards. The Yankee group of reactors is used as an example of development logic. (D.C.C.)

**19444** (RCN-102) CRITICAL EXPERIMENTS FOR THE GKN DODEWAARD NUCLEAR POWER STATION PERFORMED IN THE KRITO FACILITY OF RCN AT PETTEN. Smit, J.; Bruggink, J. C. (Reactor Centrum Nederland, Petten). Nov. 1968. 29p. Dep.

Critical experiments with fuel elements of the first Dutch nuclear power station are described. These experiments have been performed in the zero-power critical facility KRITO at RCN. After having determined a minimum critical fuel loading the reactivity effect of several fuel elements was measured. In these substitution measurements it was found that the variation of the reactivity effect of these elements is negligible. In most cases the experimental horizontal power distribution is in close agreement with the theoretical distribution. The temperature coefficient has been measured in a core without control rod followers. From this measurement and from calculations where the followers were taken into account we conclude that the temperature coefficient is negative above 25°C in the actual core of the power station. 7 references. (auth)

**19445** (TID-24960) PEACH BOTTOM ATOMIC POWER STATION MONTHLY OPERATIONS REPORT NO. 35, JANUARY 1969. (Philadelphia Electric Co., Pa.). 16p. Dep. CFSTI.

Activities at the Peach Bottom Power Reactor Unit 1 during January 1969 are described. Topics discussed include: operations; health physics and chemistry; maintenance; reactor modifications and tests results; and administration. (D.C.C.)

**19446** IMPORTANCE OF SAFETY CRITERIA FOR NUCLEAR POWER PLANTS. Jahns, A. pp 34-50 of Reaktorsicherheit und Genehmigungsverfahren. Cologne-Ehrenfeld, Institut fuer Reaktorsicherheit der Technischen Ueberwachungs-Vereine e.V., [1967]. (In German).

From Conference on Reactor Safety and Approval Procedure, Karlsruhe, Ger. See CONF-671074.

The development of guidelines and safety criteria for German power reactors is discussed. Application of the original USAEC 27 Design Criteria to the German nuclear power industry is considered. The proposal is made that safety standards can be made for reactors, as a whole; however, much effort is needed in this area. The present USAEC 70 Design Criteria are considered; incorporation of these into 10 CFR 50 is discussed. The development of German criteria is paralleled. (M.L.S.)

**19447** PROPOSAL FOR THE DEVELOPMENT OF ALLOWABLE PROCEDURES AND FORMAT OF SAFETY REPORTS. Franzen, L. F. pp 19-33 of Reaktorsicherheit und Genehmigungsverfahren. Cologne-Ehrenfeld, Institut fuer Reaktorsicherheit der Technischen Ueberwachungs-Vereine e.V., [1967]. (In German).

From Conference on Reactor Safety and Approval Procedure, Karlsruhe, Ger. See CONF-671074.

A procedure for approval of nuclear power plants in Germany is described. The proposed procedure will consider the nuclear power plant from the same viewpoint as any other commercial power plant because nuclear power is competitive with other power sources. The procedure consists of three approvals: site approval, construction approval, and operations approval. Each approval is discussed. The proposed content of the safety analysis reports required for reactor approval is described; the contents of reports for site and construction approvals are specified. (M.L.S.)

**19448** REACTOR SAFETY AND APPROVAL PROCEDURES. Kellermann, O. pp 3-18 of Reaktorsicherheit und Genehmigungsverfahren. Cologne-Ehrenfeld, Institut fuer Reaktorsicherheit der Technischen Ueberwachungs-Vereine e.V., [1967]. (In German).

From Conference on Reactor Safety and Approval Procedure, Karlsruhe, Ger. See CONF-671074.

Procedures for safety evaluation of German power reactors are described; bases for procedures are given. Time requirements for obtaining licenses are discussed. An example is constructed to illustrate the licensing processes. The role of technical codes and standards is discussed. (M.L.S.)

**19449** REAKTORSICHERHEIT UND GENEHMIGUNGSVERFAHREN. Fachgespraech in Karlsruhe, 24 Oktober 1967. (Reactor Safety and Approval Procedure, Technical Meeting held at Karlsruhe, Germany, October 24, 1967). Cologne-Ehrenfeld, Institut fuer Reaktorsicherheit der Technischen Ueberwachungs-Vereine e.V., [1967]. 72p. (CONF-671074).

The development of reactor safety and nuclear power plant approval standards and procedures is discussed. Abstracts are prepared for the three separate papers included. (M.L.S.)

*For abstracts of individual papers see: 19446–19448.*

**19450** FUTURE ROLE OF BREEDER REACTORS IN UTILITY PLANNING. Dillard, J. K.; Baldwin, C. J.; Woodley, N. H. IEEE (Inst. Elec. Electron. Eng.), Spectrum, 6: No. 3, 100-8(Mar. 1969).

Numerous considerations, chiefly related to cost, contribute to the growth pattern of electric generation. Although water reactors will undoubtedly dominate U. S. nuclear expansion into the 1980s, the high-gain fast breeder holds the greatest economic advantage over the long term. The factors leading to this conclusion are presented and analyzed, and some predictions are made for the 20-year period beginning in 1986. 12 references. (auth)

**19451** PRACTICAL PROBLEMS OF RADIOLOGICAL PROTECTION IN NUCLEAR POWER STATIONS. Delpla, M. Rev. Fr. Energ., No. 199, 239-62(Mar. 1968). (In French).

A few fundamental concepts concerning ionizing radiation and the operating principle of a power station are described. Sources of ionizing radiation, which constitute sources of danger, are discussed. Methods of protecting people from radiation (during normal operating conditions, and under accident conditions) are described. (UKAEA Info. Bull.)

**19452** INVESTIGATION OF AUTOMATIC CONTROL OF BOILING WATER REACTOR. Gritskov, V. I.; Afanas'ev, V. A.; Sankovskii, G. A.; Shugam, R. A.; Sokolov, I. N.; Solov'ev, Yu. A. At. Energ. (USSR), 25: 469-74(1968). (In Russian).

The results of experimental investigation of automatic control system of boiling water reactor VK-50 are presented. The analysis of transients of basic controlling parameters at different disturbances is given. The conclusion about the self-regulation of boiling water reactor power and some other basic parameters of the nuclear power station is made on the basis of the test data obtained. The analysis of versions of the automatic control system under the various operating conditions of the plant is carried out. (auth)

**19453** THE OPERATIONAL BEHAVIOR OF THE NEW REACTOR COMPONENTS IN THE LINGEN NUCLEAR POWER STATION. Kornbichler, Siegfried (Allgemeine Elektricitaets-Gesellschaft, Frankfurt am Main). At. Strom, 14: 172-8(Nov.-Dec. 1968). (In German).

Control-rod drives, neutron flux measuring probes, and steam separators are newly developed components in the KWL reactor. The operational behavior of these components is described. Serious difficulties were encountered only with the control-rod drives, but these were quickly and satisfactorily overcome. All components meet the requirements completely. (auth)

**19454** PROCEDURE WHEN TAKING THE LINGEN NUCLEAR POWER STATION INTO OPERATION. Jaerschky, Rudolf (Allgemeine Elektricitaets-Gesellschaft, Frankfurt am Main). At. Strom, 14: 168-72(Nov.-Dec. 1968). (In German).

A short description of the tests before operation to check the correct functioning of the components is presented. The no-load tests for checking the design of the reactor core are described. A comprehensive description is then given of the output tests from nuclear heating-up until finally the various tests were made at full load. A report is given on trial operation. (auth)

**19455** THE LINGEN NUCLEAR POWER STATION IN OPERATION. Deublein, Otmar (Kernkraftwerk, Lingen, Ger.). At. Strom, 14: 165-7(Nov.-Dec. 1968). (In German).

On October 1, 1968 the Lingen nuclear power station was handed over by the constructor to the operator. A short review of the trial operation of the nuclear power station, which is now at full net output of 245 MW, is presented. (auth)

**19456** ASPECTS OF THE PRE-OPERATIONAL TESTS AT THE LINGEN NUCLEAR POWER STATION. Koch, Manfred (Allgemeine Elektricitaets-Gesellschaft, Frankfurt am Main). At. Strom, 14: 179-82(Nov.-Dec. 1968). (In German).

The development and the importance of the tests made before operation of the reactor are described. The special viewpoints which result from these tests for the operator and the constructor are analyzed. (auth)

**19457** PHYSICAL AND THERMO-HYDRAULIC MEASUREMENTS DURING THE ACCEPTANCE OF THE LINGEN NUCLEAR POWER STATION. Schulze, Joachim; Voigt, Otfried (Allgemeine Elektricitaets-Gesellschaft, Frankfurt am Main). At. Strom, 14: 189-97(Nov.-Dec. 1968). (In German).

The reactor physics investigations are described during the zero output phase and during the output operational phase. The thermohydraulic investigations are reported (circulation of cooling medium and pressure losses, quantity and heat balances, water levels, instrumentation). Finally there is a discussion on the integral behavior of the primary circuit. (auth)

**19458** MEASURING THE DYNAMIC BEHAVIOR OF THE LINGEN NUCLEAR POWER STATION. Reinhardt, Alfred; Noack, Joachim; Sperlich, Volker; Stephan, Wendelin (Allgemeine Elektricitaets-Gesellschaft, Frankfurt am Main). At. Strom, 14: 182-8(Nov.-Dec. 1968). (In German).

When the Lingen nuclear power station was being taken into operation, a comprehensive program of measurements was made to determine the dynamic behavior of the whole installation during control phenomena, and in case of breakdowns. For this purpose over 18 transient tests were prepared, of which 75% were completed before the power station was handed over. These tests proved that the nuclear power station can meet all operational requirements. In addition it was possible to check the results of advanced calculations. The calculated settings of controls were almost precisely the optimum settings. (auth)

**19459** THE NUCLEAR POWER STATION OF STADE. Belgicatom, Ass. Belge Develop. Pac. Energ. At., Bull. Inform., 13: 3-5(Jan.-Mar. 1968). (In French).

Several sections of the reactor are illustrated. A single vertical section of the pressure vessel and a model of the thermal cycle are also given. Design specifications are presented. (BBB)

**19460** NUCLEAR PLANTS: LATE AND LATER. Olds, F. C. Power Eng., 73: No. 3, 55-62(Mar. 1969).

A comparison of the April 1967 predicted nuclear power generation growth for 1960 to 1975 with the actual trend in growth is presented. A list of utility companies and their planned power station schedules for 1968 to 1977 is presented. Reasons for the delay in nuclear power plant construction and operation are considered. (D.C.C.)

## Power Reactor Development

*Refer also to abstract 17541.*

**19461** (ANL-7527) REACTOR DEVELOPMENT PROGRAM. Progress Report, December 1968. (Argonne National Lab., Ill.). Jan. 29, 1969. Contract W-31-109-eng-38. 140p. Dep. CFSTI.

Highlights of project activities are summarized for the month of December 1968. Fuel development and reactor physics programs for the LMFBR are described. Operations for the ZPR-3, ZPR-6, and ZPR-9 during December are described. Research and development programs in the EBR-2 are described. Nuclear safety studies, including TREAT operations, and chemical separation activities are discussed. (D.C.C.)

**19462** (ANL-7548) REACTOR DEVELOPMENT PROGRAM. Progress Report, January 1969. (Argonne National Lab., Ill.). Feb. 28, 1969. Contract W-31-109-eng-38. 132p. Dep. CFSTI.

Highlights of project activities are summarized for the month of January 1969. Fuel development and reactor physics programs for the LMFBR are described. Operations for the ZPR-3, ZPR-6, ZPR-9, and ZPPR during January are described. Research and development programs in the EBR-2 are described. Nuclear safety studies, including TREAT operations, and chemical separation activities are discussed. (D.C.C.)

**19463** (EUR-4223) PERFOR 2: CALCULATION CODE FOR PERFORMANCES OF AN ORGEL TYPE REACTOR. NOMINAL PERFORMANCES, PERTURBATIONS, AND STATISTICAL HOT

CHANNEL FACTORS. Chambaud, B. (European Atomic Energy Community, Ispra (Italy). Joint Nuclear Research Center). Jan. 1969. 160p. (In French). Dep.

The PERFOR 2 computer program in FORTRAN 4 is designed for the IBM 360 computer. The program provides for the calculation of: the organic coolant temperature distribution for a cluster fuel element; the cladding temperature distribution around the most charged channel taking into account the local velocity distribution; the effects of fabrication tolerances on the nominal sheath temperature; the average thermohydraulic performance of the channels of an ORGEL-type reactor; and total performances of the reactor. (auth)

**19464** (GA-8200) HTGR BASE PROGRAM. Quarterly Progress Report for the Period Ending August 31, 1967. (Gulf General Atomic, Inc., San Diego, Calif.). Sept. 29, 1967. Contract AT(04-3)-167. 219p. Dep. CFSTI.

BERYLLIUM OXIDES—BeO–$UO_2$, fuels of, burnup of
CARBON—radiation effects on mechanical properties of, measurement of fast neutron
CARBON STEEL—pipes of, fission product plateout activity for
CESIUM—sorption in TS-688 graphite of, effects of concentration and pressure on
CONCRETES—pressure vessel of prestressed, strain analysis for
CRITICAL ASSEMBLIES—physics parameters for C/U-5000
FISSION PRODUCTS—plateout activity of GAIL 4 stainless steel and carbon steel pipes
GAMMA RADIATION—buildup in graphite and iron of, effects of source energy on
GRAPHITE—gamma buildup factor for, effects of source energy on
—sorption of cesium by TS-688, effects of concentration and pressure on
—radiation effects on swelling of CHN, H-283, H-315-A, and 711-TS-N, measurement of fast neutron
IRON—gamma buildup factor for, effects of source energy on
NEUTRONS, FAST—effects on vapor-deposited silicon carbide (SiC) coatings for 1000 MW(e) HTGR-type reactor fuels
—effects on swelling of CHN, H-283, H-315-A, and 711-TS-N graphites
—effects on mechanical properties of carbons
PLUTONIUM—diffusion in pyrolytic carbon of, effects of temperature and time on
PRESSURE VESSELS—strain analysis for 1000 MW(e) HTGR-type reactor prestressed concrete
REACTOR FUEL ELEMENTS—burnup performance of beryllium oxide (BeO) matrix uranium oxide ($UO_2$) FM-1 capsule, measurement of ETR cycles 88 and 89
REACTOR FUELS—binder removal methods for particle-type, testing of gaseous
—cycle management for 1000 MW(e) HTGR-type reactor, analysis of optimum
—coatings for 1000 MW(e) HTGR-type reactor, effects of fast neutrons on vapor-deposited silicon carbide (SiC)
REACTORS, GAS-COOLED—physics parameters for 1000 MW(e) HTGR-type, updated conceptual design
—pressure vessel for 1000 MW(e) HTGR-type, strain analysis for prestressed concrete
—kinetics for conceptual HTGR-type, two-dimensional diffusion theory and one- and two-dimensional kinetics codes for analysis of
SILICON CARBIDES—coatings for 1000 MW(e) HTGR-type reactor fuel of, effects of fast neutrons on vapor-deposited
—radiation effects on vapor-deposited coatings of, fast neutron
STAINLESS STEEL—pipes of, fission product plateout activity for
URANIUM CARBIDES—fabrication of void-diluted particle-type, performance of subsintering conversion
—fuel of, optimum coating and core thickness for particle-type
URANIUM ISOTOPES U-232—diffusion in pyrolytic carbon of, effects of temperature and time on
URANIUM OXIDES $UO_2$—BeO–$UO_2$, fuels of, burnup of (D.C.C.)

**19465** (NP-17784) ATOMICS INTERNATIONAL FAST BREEDER REACTOR PROGRAM. Balent, R.; Falcon, J. A. (Atomics International, Canoga Park, Calif.). [1968]. 16p.

The conceptual design of a 500-MW(e) Na-cooled demonstration FBR plant was completed. A contract has been signed with the General Public Utilities Corporation (New York) for participation in a development and test program leading to a decision by 1970 for the construction of the plant, in the size range of 350 to 500 MW(e). The selected site, in northeastern Pennsylvania, is in the Pennsylvania Electric Company system. Systems and components are described along with a description of the plant. Through the conceptual design phase, test requirements were identified for critical components. The overall engineering and test program is outlined. 14 references. (auth)

**19466** NUCLEAR REACTORS: THE CRITERIA OF CHOICE. Chelet, Yves (Institut National de Sciences et Techniques Nucleaires, Paris). Atomes (Paris), 23: 511-16(Sept. 1968). (In French).

Usually nuclear power reactors are grouped into 6 major types. These include the "natural U/gas/graphite" reactor, typified by the Magnox in England and the graphite/gas type in France; the "light water" or "ordinary water" reactor with its pressurized water reactor variant; the Advanced Gas Cooled Reactor, developed in England; the "heavy water" reactor, with the Candu variant and others; the high temperature reactor, including those with a Th cycle; and the "fast neutron" reactor. These are described briefly, and functioning examples pointed out. Comparison of these 6 types is made on the basis of all available data in terms of the French economy. Only 4 of the 6 may be compared. Special consideration is given to investment (which is 50% to 80% greater than that for classical power stations), including both direct and indirect costs, and to details of each combustion cycle. Fuel and moderator costs are outlined in comparison to requirements for each. (BBB)

**19467** THE NUCLEAR ENERGY IMPACT ON THE PACIFIC COAST. Worthington, J. D. (Pacific Gas and Electric Co., San Francisco). J. Petrol. Technol., 20: 795-9(Aug. 1968).

The future role of nuclear energy for power generation on the west coast of the U. S. is evaluated, particularly from economic aspects. The Pacific Slope will require the equivalent of 2 or 3 MW units to be installed each year between now and 1980, with even more units in the years to follow. Nuclear power must provide a substantial part of that installation. There is proof that nuclear power costs less than other sources in most areas. This is particularly true in high-fuel cost areas such as the Pacific Slope. The estimated cost of power from several sources, each utilizing a different kind of fuel (nuclear, gas and oil, coal, and nuclear power from the breeder reactor) is tabulated. The industry is looking ahead to commercial operation of the breeder reactor in the 1980's, which is expected to require more capital investment per Kw than today's light water reactors, but the very low fuel cost ($\frac{1}{2}$ to 1 mill less/Kw-hr) will make the breeder competitive on an over-all basis. (BBB)

**19468** PROSPECTS FOR NUCLEAR ENERGY IN WESTERN EUROPE. S. Afr. Mining Eng. J., 79: 900-6(Oct. 18, 1968).

Estimates are provided on the demands for and expected programs for nuclear power reactors in Western Europe, with emphasis on fuel requirements. The estimated total U requirements up to 2010 A.D. are given for a number of illustrative cases: continuation of proven reactor types only after 1975; recycling the Pu produced; introduction of a good advanced converter, a natural U heavy water reactor is taken as the illustration because it has the lowest U consumption; and introduction of fast reactors from 1980 (subject to the availability of Pu) supplemented as necessary by either continued installation of proven reactors or by an advanced converter using heavy water as moderator. Figures are given both for the high growth assumption and the low growth assumption. Actual programs in Western Europe will be more complex than the illustrative cases studied, and significantly lower requirements can be achieved by a judicious blend of fast reactors with both proven reactors and advanced converters. In certain circumstances, if the rate of growth of nuclear installation is high, the introduction of fast converters can significantly improve the utilization of enrichment plant, but if the rate of growth is low a fast converter would increase requirements for separative work in the short term but soon lead (because the fast converter could be switched over rapidly to Pu fuelling), to an under-utilization of this capacity. (BBB)

**19469** ADVANCES IN THE GAS-COOLED REACTOR SYSTEM. Brown, Gordon. J. Brit. Nucl. Energy Soc., 8: 46-59 (Jan. 1969).

Recent developments of the gas-cooled reactor system are reviewed. The Mark II advanced gas-cooled reactor stations under construction are described briefly and the further developments under consideration are discussed. The Mark III high temperature reactor is then described with particular emphasis on homogeneous variants. Applications extending to direct cycle electricity generation using gas turbines are discussed, and the gas-cooled fast reactor is described briefly. Anticipated generating costs and the economics for the gas-cooled reactor systems through the next decade are examined. (auth)

**19470** AVAILABILITY ASSESSMENT OF NUCLEAR PLANTS. Lahs, W. R.; Ohlenkamp, R. M. (Atomics International, Canoga

Park, Calif.). Proc. Rel. Maint. Conf., 7th, San Francisco, 1968, 119-27(1968).

From 7th Reliability and Maintainability Conference, San Francisco, Calif. See CONF-680717.

The system effectiveness approach used in the design of sodium-cooled fast reactors is described. A quantitative availability measure of both system reliability and maintainability approaches is presented. This measure, which can be converted to worth in dollars, is used in trade-off studies involving parameters such as capital, operating, and maintenance cost. Examples of these trade studies are presented. (auth)

**19471** 1968 ANNALS OF ASSURANCE SCIENCES, SEVENTH RELIABILITY AND MAINTAINABILITY CONFERENCE, SAN FRANCISCO, CALIFORNIA, JULY 14-17, 1968. Proc. Rel. Maint. Conf., 7th, San Francisco, 1968, 1-616(1968). (CONF-680717).

Seventy-nine papers are presented on the varied aspects of maintainability and reliability in the development and manufacture of industrial and utility products. A separate abstract is included for one paper, which deals with the availability of nuclear reactors. (D.C.C.)

*For an abstract of the individual paper see: 19470.*

**19472** NUCLEAR REACTOR. Wadmark, L. O. T. (to Aktiebolaget Atomenergi). Canadian Patent 801,291. Dec. 10, 1968. Priority date Apr. 1, 1965, Sweden.

The reactor described consists of a pressure vessel, with a water space in its lower portion, a steam space above the water space, a moderator tank and a means for feeding water to it. There are openings in the moderator tank to allow water to pass from it into the water space and several boiler tubes containing fissile fuel extending vertically through the tank. Superheater tubes containing fissile fuel also traverse the tank. The necessary openings in the tubes and circulation required to superheat the steam are described as well as means to prevent condensation where it would be undesirable. Inlet temperature to the moderator tank is 120°C and outlet temperature is 220°C. (F.S.A.)

**19473** NUCLEAR R AND D ORGANIZATION IN POLAND AND CZECHOSLOVAKIA. Polach, J. G. (Columbia Univ., New York). Cent. Eur. Fed., 14: No. 2, 16p(Dec. 1966).

Descriptions of the research and development institutions and organizations in Czechoslovakia and Poland are presented. The programs being investigated by the two countries are reviewed. The influence of the U.S.S.R. on the research and development programs of Czechoslovakia and Poland is described. (D.C.C.)

**19474** NUCLEAR ENERGY AS A SOURCE OF ELECTRICAL POWER. Louis, F. Electricite, No. 136, 5-16(Oct. 1968). (In French).

The installed nuclear power is doubling every two years. This installed power relies essentially on four reactor types—PWR, BWR, GCR, and HWR. The political considerations that have led to the development of these reactor types are indicated. The advantages of each type are discussed and compared with the other types. The evolution of the PWR was marked by a considerable increase in the unit capacities of the heat transfer loops. The uncertainties affecting the development of the reactor types presently in use are reported. The uranium reserves are estimated. The role of heavy water reactors is considered, and the reasons for the development of breeder reactors are given. The future of reactor development in Belgium is briefly discussed. Other uses of nuclear energy are summarized. (J.S.R.)

**19475** NUCLEAR INSTALLATIONS OF THE EUROPEAN COMMUNITY OF ATOMIC ENERGY. Belgicatom, Ass. Belge Develop. Pac. Energ. At., Bull. Inform., 13: 14-16(Jan.-Mar. 1968). (In French and Flemish).

A survey of the nuclear installations in existence, under construction, in preparation, or in the planning stage, in the member countries of Euratom is presented. An analysis of investments by member nations is also given. (BBB)

**19476** IMPROVEMENTS IN MODERATOR CORE STRUCTURES FOR NUCLEAR REACTORS. Triggs, Geoffrey William; Prince, Norman (to United Kingdom Atomic Energy Authority). British Patent 1,146,152. Mar. 19, 1969. Filed July 28, 1965.

In the structures described the core comprises an assembly of prismatic moderator material blocks, such as graphite, arranged end to end in columns and having fuel element channels and keying members fitted in keyways orientated radially relative to the axes of the blocks so as to key the blocks together. The outer blocks of the structure are secured to a rigid restraining structure by pivoted links which permit movement of the outer blocks in a direction parallel to the longitudinal axes of the columns and cause the outer blocks to follow expansion and contraction of the restraining structure. The links may also be pivoted to allow movement of the blocks at right angles to the longitudinal axes of the columns; the links may also be adjustable in length to allow some latitude in placing the outer blocks during build up of the core structure. With pivoted links it is necessary to prevent the outer blocks from rotating relative to the restraining structure. In a form suitable for use in earthquake zones the pivoted links are in flat plate form, orientated so that the planes of the plates are at right angles to the longitudinal axes of the columns with no freedom of pivotal movement in those planes. (UK)

## *Kinetics and Dynamics*

**19477** (IA-1177) SODIUM VOID AND DOPPLER EFFECTS IN LARGE FAST POWER REACTORS. Yiftah, S.; Gitter, L.; Ilamed, Y. (Israel Atomic Energy Commission, Tel Aviv). Aug. 1968. 23p. Dep.

The results obtained in previous computations for 27 Pu assemblies are analyzed. The following aspects are considered: reactivity as a function of Na leakage, Na leakage as a function of volume at normal temperature, threshold and stationary volume for variable initial Na content at normal temperature, and temperature effects. It is concluded that oxide assemblies permit the largest reactors with combined nonpositive reactivity effect, and that changes in isotopic composition of the fuel will not affect this safety factor adversely. 10 references. (auth)

**19478** A STUDY ON THE TRANSIENT BOILING BURN-OUT. 2. Sakurai, Akira; Mizukami, Koichi (Kyoto Univ.). Collect. Lect., Jap. Heat Transfer Symp., 5th, 197-200(May 1968). (In Japanese).

In understanding the transient boiling burn-out as the heating value is varied, the burn-out phenomenon, including both the steady and transient states, could be understood by incorporating the concept of the time of a nuclear boiling region for the respective heating values. As a result, it was found that even if the steady-state boiling burn-out heat flux was exceeded transiently, the situation was of no problem when the internal heating could be controlled within the time. For example, when an excess reactivity is added to the reactor by accident, the reactor power is increased rapidly, with the result of the fuel heat-flux exceeding transiently the steady-state boiling burn-out value. Then, if there exist void Doppler effects, the prompt negative reactivity coefficient is operable, leading to the control of the reactor power. (NSA of Japan)

**19479** NOISE IN POWER REACTORS: A REVIEW OF EXPERIMENT, ANALYSIS, AND THEORY. Thie, Joseph A. Reactor Fuel-Process. Technol., 11: 167-71(Fall 1968).

REACTIVITY—noise analysis for reactors, review of techniques for at-power
REACTORS—noise analysis for, review of techniques for at-power
REACTORS, POWER—noise analysis in common-type, list of intrinsic sources for (H.D.R.)

**19480** HOLD-OWN BREEDING IN THORIUM-LOADED CANDU TYPE LATTICES. Furuhashi, Akira; Shirakawa, Toshihisa (Tokyo Inst. of Tech.). Bull. Tokyo Inst. Technol. (Engl. Ed.), No. 83, 23-38(Mar. 1968).

Nuclear characteristics have been calculated on the CANDU-PHW type heavy water lattices fueled with the mixed oxides of $^{233}UO_2$–$^{235}UO_2$–$^{232}ThO_2$. The hold-own breeding of the fissile materials is found possible with the equilibrium fissile enrichment below 1.5% but the corresponding reactivity life time of the core is not very long. Slight improvement in reactivity can be obtained by increasing the reactor size and/or the lattice pitch a few centimeters beyond the original CANDU design. As a result, reasonable burnup (>10,000 MWd/t) is obtained in large scale (≳500 MW(e)) reactors with a lattice pitch of around 25 cm. Numerical calculations are performed with the point burnup computer code WATCH-TOWER-III T. The calculated results may contain some uncertainties due to the lack of an experimental endorsement. (auth) (NSA of Japan)

## *Control Systems*

**19481** THE RECENT STATE AND TRENDS OF DEVELOPMENT IN MEASURING AND CONTROL TECHNIQUES FOR PRESSURIZED-WATER POWER REACTORS. Kleinstueck, O.; Sukrow, S.; Ebersbach, H.-G.; Rehfeld, G. (VEB Kernkraftwerksbau, Berlin). Kernenergie, 11: 276-81(Nov.-Dec. 1968). (In German).

Topics discussed include: monitoring and instrumentation of the reactors; reactor control; and the control and safety system. 7 references. (auth)

**19482** APPLICATION OF COMPUTERS IN THE OPERATION OF NUCLEAR REACTORS AND POWER STATIONS. Rygl, Jaroslav (Inst. of Nuclear Research, Rez, Czech.). Jad. Energ., 15: 84-92(Mar. 1969). (In Czech).

A review of problems and experience of using computers in the operation control of nuclear reactors and nuclear power stations is presented. General principles of technical applicability of contemporary computers and the application of different systems in the practice are reported. (auth)

## *Shielding*

**19483** DIREKTE BESTIMMUNG VON TRANSMISSIONS- UND REFLEXIONS-MATRIZEN FUER GAMMASTRAHLEN. (Direct Determination of Transmission and Reflection Matrices for Gamma Rays). Hoecker, K. H.; Bagge, E.; Boehnecke, G. (eds.). Berichte der Studiengesellschaft zur Foerderung der Kernenergieverwertung in Schiffbau und Schiffahrt e. V., Hamburg, No. 11. Muenchen, Verlag Karl Thiemig KG, 1968. 47p. DM 7.80. (NP-17727).

The applicability of the invariant embedding method (the matrix method) to the calculation of reactor shielding was studied. The transmission and reflection matrices of plane layers for $\gamma$ rays were calculated with the MOTRA 1-4 program of the TR4 computer. Comparisons were made with the Double $P_1$ transport program GAMP 3 of the ER56. The principles of the theory are first given, and the program is described. The numerical results are presented. (tr-auth)

**19484** IMPROVEMENT TO BIOLOGICAL PROTECTION ARRANGEMENTS OF NUCLEAR REACTORS. (to Etablissements Neypric). British Patent 1,146,753. Mar. 26, 1969. Priority date Oct. 6, 1965, France.

GRAPHITE — shielding of gas-cooled graphite-moderated reactors by iron bars interspaced in vertical helical-grooved cylinders of

IRON — shielding of gas-cooled graphite-moderated reactors by vertical helical-grooved graphite cylinders interspaced with bars of

REACTORS, GAS-COOLED — shielding of graphite-moderated, description of vertical helical-grooved graphite cylinders and interspaced iron bars for

REACTORS, GRAPHITE-MODERATED — shielding of gas-cooled, description of vertical helical-grooved graphite cylinders and interspaced iron bars for (D.C.C.)

**19485** PRESSURE VESSELS. Young, Alexander Gillies (to English Electric Co., Ltd.). British Patent 1,146,326. Mar. 26, 1969. Filed June 11, 1965.

The concrete pressure vessel described has a cylindrical outer surface, penetrations extending longitudinally in the concrete, and radial ribs extending longitudinally on the outer surface, together with prestressing hoop cables each anchored at its ends to two of the ribs and extending part-way round the vessel within the concrete. It is preferable to employ an even number of ribs, equally spaced around the outer surface. A preferred feature is that each rib has a pair of cables anchored respectively to two circumferentially spaced sides. Each cable of the pair extends from an anchorage on the corresponding side of the rib to another anchorage on one side of the rib diametrically opposite the first rib. The cables are arranged so that they cross over each other behind the outer surface of each of the two ribs to which they are anchored, each cable passing twice through a diametral plane bisecting the two ribs. Preferably, also, at least one of the ribs is anchored between radial planes which enclose a penetration so that the rib or ribs provide reinforcement radially opposite the corresponding penetration. (UK)

## *Cooling Systems*

**19486** (ANL-7479) ANALYTICAL AND EXPERIMENTAL STUDIES OF DOUBLE-PIPE COUNTER-FLOW LIQUID METAL HEAT EXCHANGERS. Brown, Ray Wilford Jr. (Argonne National Lab., Ill.). Aug. 1968. Contract W-31-109-eng-38. 140p. Dep. CFSTI.

Thesis. Submitted to Univ. of Notre Dame, Ind.

An analytical and experimental study of heat transfer in countercurrent, liquid metal, double-pipe heat exchangers is presented. The mathematical treatment is based on an exact solution of the basic energy equation rather than on the "traditional" practice of assuming the heat transfer coefficients of individual channels to be uniform and equal to a predetermined value. The solution presented is actually an extension of the classical "Graetz" problem to boundary conditions appropriate to heat exchangers. The analysis results in a solution for the fluid temperature profiles over the entire length of the heat exchanger, including the thermal-entrance regions. The mathematical analysis was used to compute heat-exchanger efficiencies and heat transfer coefficients. The analytical results indicate that the traditional method of heat-exchanger design could lead to inaccuracies when applied to liquid metal heat exchangers. An experimental program to obtain performance curves for liquid metal heat exchangers was conducted, using a promising new technique for measuring overall heat transfer coefficients. The experimental results supported the results of the mathematical analysis, particularly for short heat exchangers, in which most of the heat transfer occurs in the thermal-entrance regions. 70 references. (auth)

**19487** IMPROVEMENTS IN OR RELATING TO POWER PLANT. Lockett, George Edward; Coast, Geoffrey (to United Kingdom Atomic Energy Authority). British Patent 1,144,172. Mar. 5, 1969. Filed May 21, 1965.

Reference is made to a high-pressure gas-cooled nuclear reactor system arranged to supply hot gas as a working fluid to a gas turbine in a direct cycle. The plant comprises a prestressed concrete pressure vessel, penetrations in the wall of the vessel for the housing of the gas turbine and a gas compressor, and a reactor core which affords a heat exchange path for heating the gas. The core is supported within the pressure vessel in a manner so as to define a space between the core and the wall of the pressure vessel. This space affords accommodation for the other necessary heat exchange paths of the cycle. The space may accommodate a gas cooler, a recuperator, inlet and outlet plenum chambers arranged to deliver gas into or receive gas from the core, and also ducting connecting the outlet plenum to the gas turbine and connecting the recuperator so as to transfer heat from the turbine effluent to the gas passing into the inlet plenum chamber. In this way ducting outside the pressure vessel is avoided, obviating the associated penalty of pressure loss and temperature drop, and also reducing cost. (UK)

**19488** SAFETY REQUIREMENTS OF REACTOR PRESSURE VESSELS IN NUCLEAR POWER STATIONS. Wiesenack, G. Tech. Ueberwach., 9: 122-8(Apr. 1968). (In German).

The principle reactor types under development are reviewed. Pressure vessel design, materials, fabrication, and testing are discussed, and German and international safety standards are outlined. (H.D.R.)

**19489** DETERMINATION OF ADSORPTION EQUILIBRIA FOR THE HELIUM-METHANE-KRYPTON SYSTEM ON ACTIVE CHARCOAL USING A DYNAMIC METHOD. Roemberg, E. (EURATOM, Brussels); Shorrock, J. C. Trans. Inst. Chem. Eng. (London), 47: No. 1, T3-10(1969).

The mixed adsorption system $CH_4$ and Kr in a He carrier gas on active charcoal at 80°K, 100°K, and 120°K was investigated at different concentrations of $CH_4$ and Kr, and the adsorption properties of the pure gas isotherms are given. The adsorption data obtained are analyzed according to several theories for predicting mixed adsorption behavior from the adsorption properties of the individual adsorbates. It is concluded that predictions for mixed adsorption from pure gas isotherms are possible with a degree of accuracy sufficient for most design purposes, and the most suitable approaches are recommended. (auth)

**19490** NUCLEAR REACTORS. Livsey, Walter Oldham; Young, Alexander Gillies (to English Electric Co., Ltd.). British Patent 1,146,327. Mar. 26, 1969. Filed June 18, 1965.

In the system described each heat exchanger unit for a gas-cooled reactor is accommodated in a separate vertical cylindrical pressure-tight penetration formed in and extending the full height of the concrete pressure vessel walls. The penetrations are spaced apart on one pitch circle and are completely encircled by concrete; they communicate with the reactor space only through coolant inlet and outlet ducts. Rotary circulators are mounted coaxially below and in the same penetration as the corresponding heat exchanger units. Dry storage means for spent fuel elements may also be provided in the penetrations. The heat exchanger units are removable. (UK)

**19491** NUCLEAR REACTORS. George, Brian Victor (to English Electric Co., Ltd.). British Patent 1,145,692. Mar. 19, 1969. Filed June 4, 1965.

Some disadvantages of present gas circulator systems in gas-cooled nuclear reactors with concrete pressure vessels are men-

tioned. In the system described each circulator is arranged with at least its rotor within the thickness of the concrete, and is removably mounted, independently of the heat exchanger system, in a hole in the concrete extending through and adapted to be sealed at the outer surface. Each circulator rotor may be mounted on a common drive shaft, and the driving motor may be mounted outside the pressure vessel. Each motor and its associated circulator may also be arranged as a single withdrawable unit. The circulators may be arranged on a horizontal axis. (UK)

**19492** OUT-OF-PILE STUDY OF THE THERMAL AND HYDRODYNAMIC PHENOMENA OCCURRING IN A POWER EXCURSION. Elberg, S.; Nyer, M. (CEN, Grenoble, France). Bull. Inform. Sci. Tech. (Paris), No. 132, 13-30(Dec. 1968). (In French).

The thermal and hydrodynamic phenomena occurring in a power excursion were measured in out-of-pile tests on a water cooled channel at low pressure (1 to 4 atm abs.). Heated walls of two different thermal diffusivity materials, aluminum and stainless steel, and both circular and rectangular test sections were used. The influence of the initial water temperature, flow rate, pressure, water height, on the temperature pressure variations, and void fraction in the test section was studied. Tests with energies up to 3000 W/cm$^2$ in 50 milliseconds were attempted. The energy above which the instabilities appear was measured. An interpretation of the observed phenomena and a simplified theoretical model are presented. (auth)

**19493** BOILING IN NUCLEAR REACTORS. Bull. Inform. Sci. Tech. (Paris), No. 132, 3-11(Dec. 1968). (In French).

The presence of steam in the cooling channels of nuclear reactors creates certain difficulties of a neutronics, hydraulic, and thermal nature. The last two aspects are being studied at the Heat Transfer Service of the CEN, Grenoble. An account of these investigations is presented. (auth)

## Fuels

*Refer also to abstracts 17518, 17522, 17543, 17697, 17698, 17733, 18255, and 18268.*

**19494** (CEA-CONF-1126) DETERMINATION OF THE TEMPORAL EVOLUTION OF A DOMAIN DEFINED BY A SYSTEM OF PARTIAL DIFFERENTIAL EQUATIONS. APPLICATION TO A NUCLEAR FUEL. Chareton, H.; Corriol, J. L.; Poulard, P. (Commissariat a l'Energie Atomique, Cadarache (France). Centre d'Etudes Nucleaires). [nd]. 20p. (In French). (CONF-680941-2). Dep.

From International Symposium on Analogue and Hybrid Computation Applied to Nuclear Energy, Versailles, France.

The analog techniques used to determine optimum peak power for a fast oxide reactor core, without fuel melting, are detailed. The heat, densification, and conservation of mass equations are formulated; constraints and boundary conditions are defined. Utilization of the discrete ordinates technique for solution to the system of partial differential equations is discussed. Procedures for setting up and solving the analog system are given; results are shown graphically. (M.L.S.)

**19495** (EURFNR-570) A METHOD FOR CALCULATING THE DESIGN STRENGTH OF FUEL CANS FOR LIQUID-METAL-COOLED FAST REACTORS. Schmidt, G. (Kernforschungszentrum, Karlsruhe (West Germany). Institut fuer Reaktorentwicklung). Translation of report KFK-808. 145p. Dep. CFSTI.

Work Performed under United States–Euratom Fast Reactor Exchange Program.

The method described can be used for calculating the size of the necessary fission gas plenum as a function of wall thickness and burn-up for the fuel rod cans of liquid metal-cooled oxide-fueled fast reactors for given material properties (especially creep behavior) and temperature and power distribution at the individual rod. A mathematical technique is applied to various examples by means of digital computer programs, and the results enable conclusions to be drawn concerning optimum fuel element design. 26 references. (auth)

**19496** (EURFNR-584) THREE FORTRAN PROGRAMS FOR DETERMINING THE HOT CHANNEL TEMPERATURES IN STEAM AND GAS-COOLED REACTOR CORES WITH ALLOWANCES FOR TRANSVERSE COOLANT MIXING. Doetschmann, K. (Kernforschungszentrum, Karlsruhe (West Germany). Institut fuer Reaktorentwicklung). Translation of report KFK-815. 29p. Dep. CFSTI.

Work performed under United States–Euratom Fast Reactor Exchange Program.

Three FORTRAN digital computer programs are presented which deal with the optimization of gas- and steam-cooled reactor fuel element design. COMIX 1 calculates the temperature in fuel rod bundles for transverse coolant mixing and isobar calculation. COMIX 2 calculates the temperatures in fuel rod bundles for transverse coolant mixing with a pressure drop. COMIX 3 calculates the temperatures of peripheral cooling channels in fuel rod bundles with transverse mixing. (D.C.C.)

**19497** CALCULATION OF FUEL COMPOSITION AND FAST POWER REACTOR PERFORMANCE IN STABLE STATE. Usynin, G. B. At. Energ. (USSR), 25: 466-9(1968). (In Russian).

A method of determining the equilibrium fuel composition in fast power reactor under the certain charging schedule of Pu burnup in the core, and different allowable burnup is considered. The composition of charged and discharged fuel and average composition of core fuel are determined by the binary equation system. The integral breeding ratio, Pu buildup rate, doubling time and change of reactivity per unit energy generated are defined. The calculation for BN-350-type reactor is presented. (auth)

**19498** CORE DESIGN FOR NUCLEAR REACTOR. Stern, Fred M. (to Combustion Engineering, Inc.). U. S. Patent 3,432,389. Mar. 11, 1969. Filed July 25, 1966.

A first core for use in a heterogeneous nuclear reactor with which batch type refueling is to be utilized so as to produce an eventual equilibrium core is described. The zone of this core from which fuel is to be finally removed is provided with a stainless steel cladding and with a decreased enrichment compared to the zone into which fuel is to be initially introduced. The fuel in this latter zone is provided with a Zr cladding. (Offic. Gaz.)

**19499** NUCLEAR REACTOR FUEL ASSEMBLY. Pawliw, J.; Hatton, G. C. (to Canadian General Electric Co., Ltd.). Canadian Patent 801,292. Dec. 10, 1968.

Fuel bundles consisting of 3, 7 or 19 elements containing pellets sheathed in Zircaloy are arranged in a string inside a circular coolant tube. Such fuel is intended for use with an organic coolant which absorbs some neutrons. To promote efficient cooling and concentrate flow over the fuel elements, filler pieces such as graphite or other low neutron absorption material are placed around the bundle periphery but not in contact with the coolant tube. Thus, the coolant flow is well distributed and may be made to remove heat efficiently from the fuel elements arranged in the form of a hexagon in the fuel channel. End fittings for fixing the position of the fuel elements and filler pieces are described. (F.S.A.)

## Auxiliary and Emergency Systems

**19500** (ORNL-TM-2478) DESIGN, CONSTRUCTION, AND TESTING OF A LARGE MOLTEN SALT FILTER. Lindauer, R. B.; McGlothlan, C. K. (Oak Ridge National Lab., Tenn.). Mar. 1969. 35p. Dep. CFSTI.

The Molten Salt Reactor Experiment uses mixtures of fluoride salts as fuel. Routine on-site processing of these molten salts results in formation of corrosion products. The development, design, construction, installation, and testing of a large salt filter to remove these corrosion products are described. The filter is designed to remove approximately 15 kg of corrosion products from 9000 kg of flush and fuel salt at a temperature of 1200°F. (auth)

**19501** APPARATUS FOR TESTING FOR NUCLEAR FUEL ELEMENT SHEATHING FAILURE. Hackney, Stanley; Davidson, Daniel Fraser (to United Kingdom Atomic Energy Authority). U. S. Patent 3,431,167. Mar. 4, 1969. Priority date July 22, 1966, Great Britain.

An apparatus for testing the occurrence of fuel element clad failure in a nuclear reactor core cooled by liquid metal is described. The apparatus detects the presence of fission products by conventional detection devices. Multiple sampling pipes carry the liquid metal from the fuel elements to the detection apparatus. The sampling pipes have flow regulated by electromagnetic pumps or electromagnetic brakes. Various alternative configurations for the detection apparatus position and sampling pipe layout are described. (Offic. Gaz.)

**19502** REACTOR COOLING SYSTEM. Kjemtrup, Jens E. (to General Electric Co.). U. S. Patent 3,431,168. Mar. 4, 1969. Filed June 26, 1967.

An auxiliary cooling system for removing decay heat from a nuclear reactor and for maintaining the coolant level in the

reactor vessel in the event that the normal circulation system must be closed is described. A pressure relief valve allows decay steam to escape into a body or pool of coolant. A portion of the escaping steam is applied to a turbine which drives a pump for supplying coolant from a storage tank to the reactor vessel to maintain the coolant level. The system thus remains operable even in the event of loss of normal and auxiliary a-c electrical power. (Offic. Gaz.)

**19503** DEVICE IN A NUCLEAR REACTOR OF THE BOILING WATER TYPE. Wadmark, L. O. T. (to Aktiebolaget Atomenergi). Canadian Patent 801,293. Priority date June 25, 1964, Sweden.

Near the top of the fuel channel, in which cooling water and steam normally flow upward, a movable nozzle is placed with a conduit attached. Cooling water from the nozzle may be sprayed downward onto the fuel element in the event of failure of the normal upward coolant flow. Another function of the nozzle is to secure a sample of steam from the fuel channel to check for fission products if a cladding failure is suspected. In normal operation the top end of fuel channel and conduit is closed off. Steam and hot water escape from a series of holes near the top of the channel. (F.S.A.)

## Operation and Economics

**19504** (HPR-104) HBWR QUARTERLY PROGRESS REPORT, OCTOBER-DECEMBER 1968. (Institutt for Atomenergi, Halden (Norway). OECD Halden Reaktor Prosjekt). Feb. 1969. 102p. Dep. CFSTI.

HALDEN BOILING REACTOR—operations during October to December 1968
—physics measurements during October to December 1968
—fuel element failures in, effects on operations of
—control system for, description of direct digital control computer
IODINE ISOTOPES I-121—fission product activity in HBWR coolant loop
RADIATION MONITORING—fuel element failure detection by HBWR gas sampling
RADIATION TARGET CANS—design parameters for HBWR instrument test assembly PEI 306
REACTOR CONTROL SYSTEMS—computer system for HBWR, description of direct digital control
REACTOR FUEL ELEMENTS—failure of HBWR, effects on operations of
—assemblies of HBWR vibrocompacted sintered-pellet Zircaloy 2-clad uranium oxide ($UO_2$), description of test
—failure of HBWR test assemblies IFA-130 and IFA-145, post-irradiation examination for (D.C.C.)

**19505** (LA-4094) QUARTERLY STATUS REPORT ON ULTRA HIGH TEMPERATURE REACTOR EXPERIMENT (UHTREX) FOR PERIOD ENDING OCTOBER 31, 1968. (Los Alamos Scientific Lab., N. Mex.). Feb. 7, 1969. Contract W-7405-eng-36. 13p. Dep. CFSTI.

Operations at UHTREX during August to October 1968 are described. Topics discussed include: operations; reactor physics; and engineering research and development. (D.C.C.)

**19506** FUTURE NUCLEAR POWER PLANS FOR SOUTH AFRICA. ATOMIC ENERGY BOARDS' REPORT OUTLINES PROGRAM. S. Afr. Mining Eng. J., 79: 192-6(July 26, 1968).

Investigation was confined to reactor types of which at least an electricity-generating prototype has been satisfactorily operated, and for which the economics of a similar commercial station are considered to have been adequately proven. Only reactor types capable of operating on natural U fuel were considered. Only two reactor types comply with these limitations: pressurized, heavy water moderated reactors and gas-cooled graphite-moderated (Magnox) reactors. The study was based on the Canadian-designed heavy water moderated and cooled Candu type. Capital requirements and water resources are discussed. (BBB)

**19507** BLACK PLANT STARTUP. Kjemtrup, J. E.; Roux, D. J. Power Eng., 73: No. 3, 39-41(Mar. 1969).

The procedures for restarting a 1000 MW boiling power reactor are described assuming external power from the utility system is not available. (D.C.C.)

**19508** ECONOMICAL BRITISH DESIGN FOR NUCLEAR POWER STATION. S. Afr. Mining Eng. J.; 79: 271-2(Aug. 2, 1968).

Prospects of nuclear power developments not previously covered have been opened up with the steam generating heavy water reactor (SGHWR) inaugurated in southwest England. Cost estimates offer in this range cheaper electricity generation than any other system. Construction at Winfrith, in Dorset, of the prototype began in May, 1963 and was completed by the end of 1967. Its design power of 100,000 kW(e) has been reached and provision has been made for increasing this generation to 120,000 kW(e). Extensive studies of varying sizes of SGHWR have shown that the dimensions of the pressure tubes incorporated in the Winfrith prototype are the correct ones to apply to much larger reactors. Nuclear plants over a wide range of outputs can be designed by simply incorporating different numbers of pressure tubes of a standard design. Development of the design of gas-cooled reactors had already reached the stage of the design of the advanced gas-cooled reactor (AGR) before construction of the SGHWR began; the second phase of the nuclear power program is based on the AGR. (BBB)

## Safety and Siting

*Refer also to abstracts 18019, 18021, and 18025.*

**19509** (AE-347) PARAMETER STUDY OF LARGE FAST REACTOR NUCLEAR EXPLOSION ACCIDENTS. Wiesel, J. R. (Aktiebolaget Atomenergi, Stockholm (Sweden)). Feb. 1969. 33p. Dep.

An IBM-code EEM (Explosive Excursion Model) was developed for calculating the energy releases associated with the explosive disassembly of a large fast reactor following a superprompt critical condition. The assumed failure chain of events and the possible core collapse following a fuel meltdown give the input data and initial conditions, the most important of which is the reactivity insertion rate at the moment of the explosive core disassembly. The dependence of the energy releases on the reactivity insertion rate, the Doppler reactivity feedback, the power form factor and the core size were studied. The model enables a quick estimation of conservative values of the destructive mechanical energy releases following a nuclear explosion and gives suggestions as to how to reduce or even avoid such excursions. (auth) (Sweden)

**19510** (AI-AEC-Memo-12790) SURVEY OF FISSION- AND CORROSION-PRODUCT ACTIVITY IN SODIUM- OR NaK-COOLED REACTORS. Zwetzig, G. B. (Atomics Internationa, Canoga Park, Calif.). Feb. 28, 1969. Contract AT(04-3)-701. 13p. Dep. CFSTI.

Data from 7 instances of fission-product release to the coolant and cover gas of Na- or NaK-cooled reactors are listed. The reactors include: SRE; HNPF; FERMI; BR-5; DOUNREAY (DFR); EBR-2; and S8ER. (D.C.C.)

**19511** (CONF-680909-, pp 1-5) PREHISTORIC SAFETY STUDIES. Teller, E. (California Univ., Livermore. Lawrence Radiation Lab.).

The criticality problems or considerations with the original gaseous diffusion separation of $^{235}U$ are described. Safety of apparatus in the early days of the gaseous diffusion plant design is considered. The formation of the first reactor safeguards committee is discussed. Some humorous anecdotes are related. (M.L.S.)

**19512** (IDO-17266) LOFT PROGRAM OFFICE. Quarterly Technical Report, July 1-September 30, 1968. Dietz, K. A. (ed.) (Phillips Petroleum Co., Idaho Falls, Idaho. Atomic Energy Div.). Feb. 1969. Contract AT(10-1)-205. 55p. Dep. CFSTI.

IODINE ISOTOPES I-131—containment of, analysis of unperturbed LOFT-ECC
PIPES—failure of pressurized-water reactor inlet, one-dimensional approximation for annular region blowdown from, (E/T)
RADIATION MONITORING—sampling system for LOFT, description of continuous
REACTOR FUEL ELEMENTS—assemblies of FHUST simulated, design parameters for
REACTOR SAFETY—blowdown in pressurized-water reactor, one-dimensional approximation for inlet pipe failure-initiated annular region, (E/T)
REACTOR SAFETY EXPERIMENTS—blowdown in LOFT quarter-scale Tests 704 and 706, measured pressure profiles for
—blowdown in LOFT quarter-scale Tests 704 and 706, WHAM computer code calculated pressure profiles for
—temperature profiles for FHUST and MOXY-simulated, comparison of
—containment during unperturbed LOFT-ECC tests, analysis of iodine-131

—sampler-monitor for LOFT, description of continuous
REACTORS, PRESSURIZED-WATER—blowdown in, one-dimensional approximation for inlet pipe failure-initiated annular region, (E/T) (D.C.C.)

**19513** (IN-1253) DEVELOPMENT OF TESTING PROCEDURES FOR PROTECTIVE COATINGS TO BE USED IN NUCLEAR REACTOR CONTAINMENT STRUCTURES. Newby, B. J.; Rohde, K. L.; Gordan, W. T. (Idaho Nuclear Corp., Idaho Falls). Feb. 1969. Contract AT(10-1)-1230. 23p. Dep. CFSTI.

Tests were designed to examine protective coatings for characteristics important in applications to the interior surfaces of boiling and pressurized water reactor containment structures. The experimental verification of these tests also served to determine that there are coating systems available that contain all the desired physical and chemical characteristics.

**19514** (ORNL-NSIC-37) FISSION PRODUCT RELEASE AND TRANSPORT IN LIQUID METAL FAST BREEDER REACTORS. Keilholtz, G. W.; Battle, G. C. Jr. (Oak Ridge National Lab., Tenn.). Mar. 1969. Contract W-7405-eng-26. 152p. Dep. CFSTI.

A state-of-the-art review of fission product behavior in liquid metal systems is presented. Topics discussed include: fuels and fuel elements for fast reactors; fission product release from reactor fuel; fission product retention in and release from liquid Na systems; Na fires in reactor containment systems; fission product transport and sodium oxide aerosols; sampling, characterization, and filtration of Na fission product aerosols; and experience with reactor designs, fuel meltdowns, and fission product release. (D.C.C.)

**19515** COOLANT EJECTION MECHANISMS FOR USE IN ANALYZING FAST REACTOR SAFETY. Fauske, Hans K. Reactor Fuel-Process. Technol., 11: 180-6(Fall 1968).

FLUID FLOW—ejection mechanisms for liquid metal-cooled fast breeder power reactor coolant, computer programs for analysis of, (T)
REACTOR SAFETY—coolant ejection mechanisms for liquid metal-cooled fast breeder reactor, computer program models for analysis of, (T)
REACTORS, BREEDER—coolant ejection mechanisms for liquid metal-cooled fast power, computer program models for analysis of, (T)
REACTORS, FAST—coolant ejection mechanisms for liquid metal-cooled breeder power, computer program models for analysis of, (T)
REACTORS, LIQUID METAL-COOLED—coolant ejection mechanisms for fast breeder power, computer program models for analysis of, (T)
REACTORS, POWER—coolant ejection mechanisms for liquid metal-cooled fast breeder, computer program models for analysis of, (T) (D.C.C.)

**19516** A SAMPLING DEVICE FOR TAKING GAS SAMPLES. (to Brown Boveri/Krupp Reaktorbau GmbH). British Patent 1,145,509. Mar. 19, 1969. Priority date Aug. 21, 1965, Germany.

REACTORS, GAS-COOLED—coolant sampling in, description of valve-regulated gas-tight filling head for multiple-point (D.C.C.)

### *Power Conversion Systems*

**19517** (CEA-CONF-1124) SIMULATION OF INCIDENTS IN SODIUM-HEATED STEAM GENERATORS BY MEANS OF ANALOG COMPUTERS. CARES PROGRAM. Trimouille, C.; Cambe, H. (Commissariat a l'Energie Atomique, Cadarache (France). Centre d'Etudes Nucleaires). [1968]. 52p. (In French). (CONF-680941-5). Dep.

From International Symposium on Analogue and Hybrid Computation Applied to Nuclear Energy, Versailles, France.

The development of an improved mathematical model for calculating the principal characteristics of the Na–water reaction in steam generators for Na cooled reactors is detailed. Equations are set up for Na loop pressure, and Na entry and exit heat balances; heat balance equations are listed for the $H_2$, Ar, and water loops. Use of the analog computer for solution to the equations is discussed. Simplified schematics of the physical system are shown; diagrams showing the steam generator and analog circuits are given. Couple curves generated from the analog simulation are included. (M.L.S.)

**19518** SATURATED-STEAM TURBINES FOR NUCLEAR POWER STATIONS. Hohl, R. (Escher Wyss Ltd., Zurich). Escher Wyss News, 40: 3-15(1967).

The low-temperature end of a large turbo-set, droplet formation in wet steam, the erosive action of droplets on the blading, protective measure for erosion reduction, and the selection of suitable materials for saturated-steam turbines are described. An erosion factor is proposed as a new criterion for the loss rate of material. Moreover, the effects on cycle efficiency of the water separator and also of a steam-heated reheater are considered in detail. Some further design problems are considered, with examples of complete turbine units. (auth)

**19519** STEAM GENERATORS FOR NUCLEAR POWER STATIONS. Krizek, Vladimir (Research Inst. for Power Equipment, Brno). Jad. Energ., 15: 73-84(Mar. 1969). (In Czech).

A summary of the design problems of steam generators for nuclear power stations and a review of the rapid world development are given. The Czechoslovak contribution in this field to the world development is included. (auth)

## Research and Test Reactors

*Refer also to abstracts 17643, 17645, 17674, 17786, 17817, 18191, 18249, 19444, 19461, 19462, 19510, and 19512.*

**19520** (AAEC/TM-479) ANALOGUE STUDIES OF POWER TRANSIENTS FOLLOWING LOSS OF A SINGLE COARSE CONTROL ARM BLADE IN THE MATERIALS TESTING (DIDO-TYPE) REACTOR HIFAR. Corran, E. R.; McCulloch, D. B. (Australian Atomic Energy Commission Research Establishment, Lucas Heights). Sept. 1968. 50p. Dep.

Analogue computer studies have been made of the power transients resulting from the loss of a single coarse control arm blade in the materials testing (DIDO-type) reactor HIFAR. A point reactor model without reactivity feed-back was assumed, and parameters covering a wide range of core conditions were studied. Operating limitations for avoidance of core damage in such an accident are suggested on the basis of some assumed safety criteria. (auth)

**19521** (BNWL-952) ANNULAR INLET FFTF HYDRAULIC FEATURE MODEL. Jackson, P. M. (Battelle-Northwest, Richland, Wash. Pacific Northwest Lab.). Jan. 1969. Contract AT(45-1)-1830. 28p. Dep. CFSTI.

The FFTF annular inlet concept is an arrangement for introducing reactor coolant through the annular zone formed between the reactor vessel and the reactor core vessel. This concept eliminates the need for piping to the supply plenum and provides a zone for inlet coolant mixing. This reactor concept was studied using a $1/10$ scale model with four equally spaced inlet pipes located perpendicularly to the vertical axis. The model was designed using Euler number equality and constructed of clear plastic to permit visual observation of the flowing water modeling fluid. The testing was performed to evaluate the mixing characteristics of the water and to reveal any unsuspected hydraulic behavior. Motion picture analysis at flow rates from 10 to 100% with both balanced and unbalanced conditions was the main analysis tool employed. Results are presented. (auth)

**19522** (CEA-CONF-1086) CONTROL OF ATMOSPHERIC CONTAMINATION BY TRITIATED WATER VAPOR NEAR THE EL.3 REACTOR AND COMPARISON OF RESULTS OBTAINED WITH RADIOTOXICOLOGIC MEASUREMENTS. Fitoussi, L.; Jockey, P.; Lebouleux, P. (Commissariat a l'Energie Atomique, Saclay (France). Centre d'Etudes Nucleaires). [1968]. 16p. (In French). (CONF-681013-3). Dep.

From 1st European Congress on Radiation Protection and Exhibition on Equipment Using Low Energy and Short Range Radiation Dosimetry, Menton, France.

The EL-3 reactor is a heavy water reactor with 4.5% enriched uranium oxide fuel, whose annual increase of the tritium concentration in the heavy water is of the order of 9%. This concentration at the present is about 3.5 Ci/l. Leaks in the coolant circuit lead to a low-level permanent atmospheric contamination of the premises of the reactor by tritiated water vapor. The concentration of this atmospheric contamination can be increased significantly, but momentarily, during experiments by incidents. The rate of atmospheric contamination can vary within wide limits ($10^{-2}$ to $10^3$ MPC) and the detection of this radioactive danger necessitated the development of the three measurement techniques described: liquid scintillation, ionization chamber, and circulation proportional counter. The systematic measurements made for several years made it possible to determine the mean atmospheric contamination rate of different sites in the reactor and to estimate the internal irradiation risks for workers. They correspond, according to the locations, to absorbed dose equiva-

lents between 300 and 1200 mrems/yr for a continuous exposure and between 15 and 800 mrems/yr for an exposure reduced to the work time in the contaminated atmosphere. These results were compared with those obtained from practical radiotoxicological examinations by the Medical Service on the urine of workers at the EL-3 reactor. These examinations confirmed the effect of the work post on the internal irradiation and showed that the absorbed dose equivalents effectively received by the workers is distributed, for all the work posts, between a value below the sensitivity limits of the examinations (about 10 mrems/yr) and 600 mrem/yr. These comparisons show a good agreement between the results obtained with a displacement toward the low values of the radiotoxicological results. These results led to the installation of devices for monitoring of the workers and to the improvement of the ventilation system of the EL-3 reactor. (tr-auth)

**19523** (CEA-CONF-1118) CYRANO CAPSULE. DIRECT MEASUREMENT METHODS OF POWER DEPOSITED BY NEUTRONS IN FISSILE SAMPLES. Pleyber, G.; Berger, J.; Drouleers, Y. (Commissariat a l'Energie Atomique, Grenoble (France). Centre d'Etudes Nucleaires). June 9, 1967. 20p. (In French). (INT/Pi(NT)-564-92/67; CONF-681039-3). Dep.

From Euratom Conference on Irradiation Equipment, Grenoble, France.

The Cyrano capsule was designed for in-pile testing of fuel rods under conditions of specific power, clad temperature, and controllable ambient pressure in order to make the conditions equivalent to that of the power reactors using this fuel. The capsule has a built-in calorimeter which permits the continuous measurement throughout the irradiation of the power released in the sample whether it comes from fission or $\gamma$ radiation. The determination of the contribution of these different processes of energy release of the total heating is possible by two different methods. The comparison of these two methods shows that there is very good agreement between the results. The first method, using a differential analysis of the total power by means of signals given by the collectors and calorimeters, is valid only in the case where there is proportionality between the power released by fission in the fuel and the signal of the neutron flux monitor. This is realized for uranium rods only at the beginning of the irradiation. The second method consists of measuring separately the power released by the $\gamma$ rays of the reactor by the use of a $\gamma$ mockup and from a Cyrano capsule without fuel. This method is applicable to all types of fuel rods and to all degrees of burnup. (tr-auth)

**19524** (CEA-R-3626) EXPERIMENTAL STUDY OF THE RAPSODIE PROTECTIONS. Chapelet, Marcel; Edeline, Jean-Claude; Lhiaubet, Gilbert (Commissariat a l'Energie Atomique, Fontenay-aux-Roses (France). Centre d'Etudes Nucleaires). Oct. 1968. 192p. (In French). Dep.

Details of the protection tests which have been carried out by the Protection Sub-Commission during the starting-up trials on the reactor RAPSODIE are described. The main types of tests reported concern the flux measurements in the core, the reflectors, the Na and the near biological protections, the radioprotection measurements in the premises, and the activation of the principal fluids. The results obtained are analyzed and compared to predicted calculations. (auth)

**19525** (GA-9093) EXPERIMENTAL TEST OF THE FREVAP-8 CODE FOR CALCULATING METAL FISSION PRODUCT RELEASE FROM HTGR FUEL ELEMENTS. de Nordwall, H. J.; Pierce, V. H.; Zumwalt, L. R. (Gulf General Atomic, Inc., San Diego, Calif.). Nov. 1, 1968. Contract AT(04-3)-167. 9p. Dep. CFSTI.

In the FREVAP-8 calculation it is assumed that the migration of fission product metals such as Ba and Sr through the fuel-free graphite that separates HTGR-type fuel from the He coolant can be represented by steady-state diffusion equations. Observed and calculated releases from experimental fuel elements irradiated in the PLUTO loop of the DIDO, and the GAIL loop of the GETR are compared. Results are presented. 5 references. (D.C.C.)

**19526** (GA-9198) LATTICE PHYSICS STUDIES. Quarterly Progress Report for the Period Ending December 31, 1968. Trimble, G. D.; Neill, J. M. (Gulf General Atomic, Inc., San Diego, Calif.). Jan. 17, 1969. Contract AT(04-3)-167. 25p. (EURAEC-2089). Dep. CFSTI.

Work Performed under United States–Euratom Joint Research and Development Program.

Thermal neutron spectrum measurements were performed in the 1.3 inch pitch lattice of Al–Pu fuel elements which has a volume ratio of water of 6.03. These measurements were performed at room temperature using time-of-flight techniques. The fabrication of the experimental tank for studying thermal neutron spectra in plutonium nitrate solutions is described. The on-line checkout testing of the tank and glove box system is described. (D.C.C.)

**19527** (IN-1260) REACTOR PHYSICS RESULTS FROM LOW-POWER MEASUREMENTS IN THE ADVANCED TEST REACTOR. Kaufman, N. C.; Durney, J. L.; Tappendorf, J. C.; Willis, J. B. (Idaho Nuclear Corp., Idaho Falls). Feb. 1969. Contract AT-(10-1)-1230. 50p. Dep. CFSTI.

Power distribution and outer shim calibration data show that the outer shim modifications following the initial ATR startup did not change the previously demonstrated ATR-ATRC nuclear correspondence. The outer shim calibration data also indicate that the small difference in excess reactivity, ≈0.3 $, between ATR and ATRC is the same as observed previously. Increasing the reactor coolant temperature caused only slight changes (≈2% in safety rod and shim worths. Increasing the loop coolant temperatures caused a 9% decrease in the No. 1 neck shim set worth, a 12% increase in outer shim S34 worth, and only slight changes in regulating rod and safety rod worths. Fast (>1 MeV) neutron flux and $\gamma$ heating measurements produced data with the expected axial cosine distributions. Comparison of these data with ATRC data indicates that ATR fast neutron flux and $\gamma$ heating (for positions near the fuel) can be predicted from low power ATRC measurements with 5 and 20 percent uncertainties, respectively. Noise measurements produced a value of 25.2 ± 0.3 Hz for $\beta/A$, as expected. The power spectral density from zero-power measurements shows prominent resonances resulting from vibration of the in-pile experiment tubes. (auth)

**19528** (NP-17788) DOSE RATES OF NEUTRONS AND GAMMA RAYS NEAR THE BIOLOGICAL SHIELD OF THE VVR-S REACTOR. Makra, Z.; Tot, M. (Magyar Tudomanyos Akademia Kozponti Fizikai Kutato Intezete, Budapest). [1968]. 24p. (In Russian). Dep.

VVR-S was rebuilt and changes made in the shield and in beam holes. Measurements were made with reactor at 3.2 MW. Results are compared with similar measurements made in 1967. The dose rate is now lower than before even though the power is higher. 8 references. (auth)

**19529** (ORNL-TM-2467) TUBE VIBRATION IN HFIR HEAT EXCHANGERS. Fraas, A. P. (Oak Ridge National Lab., Tenn.). Mar. 1969. Contract W-7405-eng-26. 25p. Dep. CFSTI.

Three instances of water leakage from the primary to the secondary water circuits of the HFIR have occurred during hot, humid weather in the past three years. These leaks were traced to broken tubes in the intermediate heat exchangers. Analyses and experiments demonstrate that the failures stemmed from hydrodynamically induced tube vibration when the secondary system water flow rate through the individual heat exchangers has been raised above the design value during periods of hot, humid weather. The reactor operating procedure has been changed so that, in the future, the secondary system water flow rate per heat exchanger will be kept below the design value. (auth)

**19530** (Y-DR-7) CRITICALITY RESEARCH AT THE OAK RIDGE CRITICAL EXPERIMENTS FACILITY. Thomas, J. T. (Union Carbide Corp., Oak Ridge, Tenn. Y-12 Plant). 1968. Contract W-7405-eng-26. 31p. (CONF-681101-13). Dep. CFSTI.

From International Conference on the Constructive Uses of Atomic Energy, Washington, D. C.

Criticality studies are described for $UF_6$ shipping containers, HFIR core storage, 25 annular uranium billets, borosilicate glass and uranyl-nitrate solutions, unreflected and reflected uranyl-nitrate solutions, and spherical units with fissile material, density for constant cell volume. (D.C.C.)

**19531** THE VARIOUS AUTOMATION MODES USED IN THE CONTROL OF NUCLEAR REACTORS. di Giacomo, C. Chim. Ind., Genie Chim., 100: 410-8 (Sept. 1968). (In French).

Illustrations of different problems are given for the ESSOR reactor control. The control of the heavy water circuits and of the emergency auxiliary power supply by control functions is outlined. The general arrangement of sequential control through wiring logic is described. Process monitoring, particularly safety control of reactivity, is carried out by a system employing a digital process computer. The computer is described with respect to functions, construction, and on-line testing to determine error in data treatment. The construction and on-line testing of the emergency stop logic circuits (scram logic) of the reactor are described. Problems of devising automation for experimental reactors are sketched; these arise mainly from incompatibility of requirements for functioning with those appropriate to computer monitoring. (BBB)

**19532** HEALTH PHYSICS CONSIDERATIONS IN THE OPERATION OF SANDIA PULSED REACTOR II. Christiansen, H. D.;

Golden, J. C. (Sandia Lab., Albuquerque, N. Mex.). Health Phys., 16: 489-96(Apr. 1969).

Sandia Pulsed Reactor II is a Super-Godiva designed to produce, over a small internal sample volume, a fast neutron fluence of $10^{15}$ n/cm$^2$ in a 30 μsec pulse. Health physics problems encountered in the use of this reactor were studied by making radiation dose rate measurements while the reactor was being operated at steady state. Radiation doses were calculated from the experimental data for the design maximum burst yield of $1.7 \times 10^{17}$ fissions. Contamination problems were evaluated, and an estimate of the fission product release from the fuel assembly was made. (auth)

**19533** KAZAKHSTAN SCIENTIFIC-RESEARCH REACTOR VVR-K. Takibaev, Zh. S.; Batyrbekov, G. A.; Okolovich, V. N.; Yurovskii, L. A. Vestn. Akad. Nauk Kaz. SSR, No. 9, 3-12(Sept. 1968). (In Russian).

A description of the VVR-K research reactor and its experimental facilities is presented. Startup physics measurements are presented. Control rod calibration curves are included. (tr-auth)

**19534** DISCREPANCY BETWEEN MEASURED AND CALCULATED REACTIVITY COEFFICIENTS IN DILUTE PLUTONIUM FUELED FAST CRITICALS. Little, W. W. Jr.; Hardie, R. W. (Battelle Memorial Inst., Richland, Wash.). Contract AT(45-1)-1830. Nucl. Sci. Eng., 36: 115-16(Apr. 1969).

The discrepancy between calculated and measured central small-sample absolute reactivity coefficients in dilute plutonium-fueled critical assemblies are discussed, and some possible sources of error are examined. 11 references. (H.D.R.)

**19535** EVALUATION OF HOMOGENEOUS AND HETEROGENEOUS METHODS OF ANALYSIS IN A REFLECTED SUBCRITICAL ASSEMBLY. Haroon, M. R. (Georgia Inst. of Tech., Atlanta). Nucl. Sci. Eng., 36: 116-22(Apr. 1969).

Critical parameter measurements were made on small numbers of fuel elements to determine if accurate criticality predictions can be made for a reactor system without filling the whole assembly. Results of homogeneous and heterogeneous analysis methods are compared and correlated with the experimental results. It is concluded that the use of heterogeneous two-group calculations or numerical methods such as CRAM enable accurate criticality predictions from measurements on limited quantities of fuel. 10 references. (H.D.R.)

**19536** THE DECONTAMINATION OF A REACTOR WATER COOLANT LOOP, DEMONSTRATED AT THE ROSSENDORF WWR-S TYPE RESEARCH REACTOR. Unger, H.; Westphal, D. (Staatliche Zentrale fuer Strahlenschutz, Lohmen, Ger. Zentralinstitut fuer Kernforschung, Rossendorf, Ger.). Kernenergie, 11: 285-90(Nov.-Dec. 1968). (In German).

The decontamination of the primary cooling system of the Rossendorf WWR-S type research reactor is described. Detailed investigations of adequate decontaminating solutions resulted in using a solution essentially containing oxalic acid which seemed to be useful for decontaminating a combined loop consisting of austenitic steel and pure Al. The maximum effect of decontamination was 94 per cent found with the measurement of the local dose rate in the room of the primary coolant loop carried out before, during, and after decontamination. The data found are in good agreement with those obtained in the laboratory. (auth)

**19537** MEASUREMENT OF THE TRANSIENT CONTROL ROD MOTION AND ITS EFFECT ON THE AFRRI-TRIGA REACTOR PULSE. Leonard, B. E.; Hughes, D. A. (Armed Forces Radiobiology Research Inst., Bethesda, Md.). Nucl. Instrum. Methods, 69: 157-62(Mar. 1969).

The design of a transient control-rod-motion measuring system for the AFRRI-TRIGA pulse reactor is presented. Schematics of the photodiode sensing circuit and power supply circuits are shown; a block diagram of the transient rod displacement system is included. Control rod displacement and relative power are shown as functions of times for various pulse sizes. Effects of variation of air solenoid pressure on the pulse are detailed. Power traces for theoretical and experimental prompt jump, for the same reactivity insertions, are shown. (M.L.S.)

**19538** BIMODAL DECAY OF TWO PULSED-NEUTRON-COUPLED CORES OF AN ORGANIC-MODERATED AND -REFLECTED SYSTEM. Farinelli, U.; Pacilio, N. (Comitato Nazionale Energia Nucleare, Rome). Nucl. Sci. Eng., 36: 39-46 (Apr. 1969).

Pulsed-neutron experiments have been made on two organic-moderated and -reflected coupled cores of the ROSPO (a zero-power organic-moderated reactor) nuclear system in order to investigate their time response and to measure some kinetic parameters. At least for loose coupling, the fundamental mode has been observed to have two time-decay constants in any point of the system (except in the vertical symmetry plane), which are strongly interrelated. For two identical cores, these decay constants can give separate information on the intrinsic and coupling reactivity as well as on the reduced neutron lifetime of the system. 8 references. (auth)

## Rocket and Space Reactors

*Refer also to abstracts 17541, 17878, 17880, 18196, and 19510.*

**19539** (N-68-11960) [NERVA PROGRAM]. Summary Report No. 6 [for] Period Ending September 30, 1967. (Aerojet-General Corp., Sacramento, Calif.). Nov. 1967. Contract SNP-1. 599p. (NASA-CR-91051; RN-A-0010). CFSTI.

Major efforts on the NERVA engine development program are identified as (1) mating the experimental engine cold flow with the engine test stand; (2) upgrading the fuel endurance capability to ensure achievement of the 60-min full power full duration objective for NRX-A6; (3) radiation effects tests including explosive materials, structural materials, and pressure transducer; and (4) design and parametric analyses. The technical discussion covers propellant feed system, reactor system integration, thrust chamber assembly, engine controls, systems analysis, mechanical and electrical ground support equipment, instrumentation, ground operations safety, product assurance, flight malfunction, nonfuels materials, and special test equipment. Program management and the support and operations of the Nuclear Rocket Development Station are also discussed. (STAR)

**19540** (UCRL-50429) FAST REACTOR DESIGN ANALYSIS CODES. Brown, Norman J.; McCauley, Edward W. (California Univ., Livermore. Lawrence Radiation Lab.). July 3, 1968. 294p. Dep. CFSTI.

A consistent method of nuclear reactor design analysis useful for survey or specific program requirements is presented. The method exemplified treats the advanced, fast spectrum, uranium mononitride systems associated with the Lawrence Radiation Laboratory Space Power Program. In addition to detailing the specific techniques used to couple the mechanical-thermal/neutronic analysis, a complete code listing for both convectively cooled and heatpipe reactors is given. A 16-group interim cross section library, weighted for various fast spectrum reactors, as well as a generalized thermal spectrum system, is included. The specific neutronic analysis used is a stripped version of the DTF-II transport code to which additional $S_n$ quadrature set user information has been added. (auth)

**19541** NUCLEAR PROPULSION FOR SPACE. Schreiber, R. E. (Los Alamos Scientific Lab., N. Mex.). J. Brit. Nucl. Energy Soc., 8: 31-45(Jan. 1969).

Development work on the Rover Project is discussed. Following a brief history of the Project, the reactor aspects are discussed in some detail. The flight engine NERVA-1 is described, and the basic reactor types KIWI A, KIWI B, PHOEBUS-1, and PHOEBUS-2 are compared. Problems facing the design engineer are considered, and testing station procedures are described. (UK)

**19542** THERMAL CHEMICAL ROCKET. Muenzberg, Hans Georg; Buechner, Ernst-Eberhard (Technische Hochschule, Munich). Z. Flugwiss., 16: 416-9(Nov. 1968). (In German).

A proposal for a combined propulsion system for spaceflight, the nuclear/chemical rocket, is made. A mode of construction of such a unit is illustrated; three arrangements for operation are possible, including combined nuclear and combustion chamber operation and individual operation of either component. The advantages of operating in each of these ways are described for various parts of a space flight. Calculations for the unit under the assumptions of equilibrium expansion, chamber pressure of 50 bar, flash pressures of 1.0 and 0.01 bar, and appropriate loss-free jets are given; these include exit plasma velocities, and various thermodynamic properties of the unit. Comparison to purely chemical and purely nuclear rocket can be in fact made only after detailed technological study and detailed project analyses. (BBB)

**19543** COMPACT POWER CONCEPT FEATURES A FAST REACTOR, HEAT PIPES, AND DIRECT CONVERTERS. Roberts, John J.; Croke, Edward J. Reactor Fuel-Process. Technol., 11: 187-200(Fall 1968).

BERYLLIUM OXIDES—physical properties of
CRITICALITY STUDIES—measurements for optimum beryllium oxide (BeO)-reflected plutonium phosphide (PuP)-fueled heat-pipe thermoelectric fast reactor core configuration
HEAT PIPES—design parameters for conceptual 1 to 5 kW(e) plutonium phosphide (PuP)-fueled thermoelectric fast reactor

NUCLEAR AUXILIARY POWER SYSTEMS—design parameters for conceptual 1 to 5 kW(e) plutonium phosphide (PuP)-fueled heat-pipe thermoelectric fast reactor
PLUTONIUM PHOSPHIDES—physical properties and nuclear properties of
RADIATORS—design parameters for conceptual 1 to 5 kW(e) plutonium phosphide (PuP)-fueled heat-pipe thermoelectric fast reactor
REACTIVITY—measurement of beryllium oxide (BeO)-reflected plutonium phosphide (PuP)-fueled heat-pipe thermoelectric fast reactor, effects of configuration on optimum
REACTOR FUEL ELEMENTS—design parameters for conceptual 1 to 5 kW(e) fast thermoelectric reactor hexagonal-shaped heat-pipe-containing plutonium phosphide (PuP)
REACTORS, FAST—design parameters for conceptual 1 to 5 kW(e) plutonium phosphide (PuP)-fueled heat-pipe thermoelectric
REACTORS, POWER—design parameters for conceptual 1 to 5 kW(e) plutonium phosphide (PuP)-fueled heat-pipe thermoelectric fast
THERMOELECTRIC CELLS—design parameters for conceptual plutonium phosphide (PuP)-fueled heat-pipe fast reactor 1 to 5 kW(e) (D.C.C.)

## Marine and Portable Power Reactors

**19544** (RCN-97(Vol.1)(Pt.1)) NERO DEVELOPMENT PROGRAM. VOLUME I. DESCRIPTION. PART I. FINAL DESIGN OF THE NERO SHIP PROPULSION PLANT. Final Report. (Reactor Centrum Nederland, [The Hague]). May 1968. Contract 007-61-6-PNIN. 494p. Dep.

Information on the NERO ship propulsion plant program is presented under the following broad topics: Introduction; Summary; Basic Design Considerations; Selection of Main Plant Parameters; Plant Design Description; Waste Disposal; Refueling Procedure; and Analysis of Hazards. (D.C.C.)

**19545** (RCN-97(Vol.2)(Pt.1)) NERO DEVELOPMENT PROGRAM. VOLUME II. SYMBOLS AND DRAWINGS. PART I. FINAL DESIGN OF THE NERO SHIP PROPULSION PLANT. Final Report. (Reactor Centrum Nederland, [The Hague]). May 1968. Contract 007-61-6-PNIN. 168p. Dep.

Instrumentation symbols and circuits, design drawings, flow diagrams, data plots, and component illustrations are presented for the NERO ship propulsion plant program. (D.C.C.)

**19546** NUCLEAR MERCHANTMEN: TODAY AND TOMORROW. Nav. Eng. J., 80: 711-16(Oct. 1968).

Future prospects of nuclear-powered cargo ship construction are reviewed, particularly economic aspects. The nuclear ship Savannah's successful operating record on commercial voyages to Northern European, Mediterranean, and Southeast Asian ports is cited. The 30 to 50% higher construction costs for nuclear ships compared with conventionally powered ships with the same shaft horsepower and carrying capacity is cited. However, this type of initial cost comparison may be misleading. It is expected that future generations of nuclear ships will be economically competitive with conventional ships. (BBB)

## Production Reactors

**19547** (DP-MS-68-27) XENON CONTROL AT SAVANNAH RIVER. Roggenkamp, P. L. (Du Pont de Nemours (E. I.) and Co., Aiken, S. C. Savannah River Lab.). Feb. 27, 1968. Contract AT(07-2)-1. 23p. (CONF-680325-1). Dep. CFSTI.

From Meeting on Reactivity and Spatial Neutronic Effects in Large Water Reactors, Washington, D. C.

A description of the Savannah River Production Reactor is presented. Analytical techniques for calculating the Xe effects on the power distribution in the reactors are described. The operational considerations of Xe control are discussed. (D.C.C.)

## Reactor Theory

*Refer also to abstracts 17541, 19119, 19121, 19123, and 19127.*

**19548** (CONF-680909-, pp 12-17) THE USE OF THE MONTE CARLO METHOD TO SAMPLE FROM THE ADJOINT NEUTRON TRANSPORT EQUATION. Carter, L. L.; McCormick, N. J. (Washington Univ., Seattle. Dept. of Nuclear Engineering).

Use of existing Monte Carlo techniques and codes for adjoint sampling and determination of adjoint scattering probability density functions is discussed. The development of sampling scheme which uses the nonunit weighting of pseudorandom neutrons from a scattering collision is described; the utility of this zero-variance sampling scheme is evaluated. The development of a coupled sampling technique is described; an example using this technique is discussed. 7 references. (M.L.S.)

**19549** (EURFNR-604) A STATISTICAL METHOD FOR EVALUATION OF HOT CHANNEL FACTORS IN REACTOR DESIGN. Amendola, A. (Kernforschungszentrum, Karlsruhe (West Germany). Institut fuer Reaktorentwicklung). July 1968. 44p. (KFK-843; EUR-3979). Dep.

Work performed under United States–Euratom Fast Reactor Exchange Program.

Previous methods of hot channel analysis assumed all the cooling channels in a core to be independent. Actually we have to distinguish between two types of uncertainties, namely: local uncertainties, which may vary from point to point within a reactor, and global uncertainties which do not vary within a reactor, or at least within parts of a reactor. The global uncertainties introduce evidently a correlation among the temperatures of the coolant in the channels they affect in the same way. A quantitative assessment of the different effects of these two types of uncertainties is presented, and a new method of evaluating the hot channel factor, taking into account this correlation, is proposed. The method was developed with reference to Na-cooled fast reactors, but is quite general and may readily be applied to other reactor types. An example is presented for the reactor Na-2, and a comparison with the previous methods is described. The actual temperature profile of the coolant in the reactor is taken into account. 18 references. (auth)

**19550** (FEI-118) METHOD OF SUCCESSIVE APPROXIMATIONS AS APPLIED TO A SOLUTION OF THE PARTIAL PROBLEM OF A NUCLEAR REACTOR SPECTRUM. Kolosov, B. I. (Gosudarstvennyi Komitet po Ispol'zovaniyu Atomnoi Energii SSSR, Obninsk. Fiziko-Energeticheskii Institut). 1968. 26p. (In Russian). Dep. CFSTI.

A generalized, successive-approximation method was developed to calculate the eigenvalue and eigenfunction spectrum of a one-dimensional reactor, using the multigroup diffusion approximation. The derived algorithm allows the reactor equation for neutron density to be solved and the fission neutrons to be determined. The properties of the eigenvalues and eigenfunctions of the reactor equation are examined on the basis of diffusion-absorption Green function operators. The finite-difference method, which is based on the substitution of the differential operators and boundary conditions by finite-difference analogs, was used for the numerical computation. A reactor with 5-layer thickness in the x direction and infinite thickness in the other dimensions was used for the calculations in the two-group diffusion approximation. (TTT)

**19551** (ORNL-TM-1967) MONTE CARLO PATH LENGTH SELECTION ROUTINES BASED ON SOME SPECIFIC FORMS OF THE IMPORTANCE FUNCTION. Cain, V. R.; Straker, E. A.; Thayer, G. (Oak Ridge National Lab., Tenn.). Feb. 6, 1969. 39p. Dep. CFSTI.

One of the more fruitful techniques for importance sampling in Monte Carlo calculations is that of modifying the path length selection in the random walk. The simplest practical approach is usually referred to as the "exponential transform" and assumes that the value, or importance, function (which gives the value of a collision in the random walk to the answer of interest) is a simple exponential in space. In many cases of interest, more detailed information is available about the actual value function and a more complicated form of the importance function can be assumed. The formalisms and computer listings are given for some of these specialized importance functions which have been implemented in the path length selection routines of the 05R Monte Carlo code. (auth)

**19552** (WAPD-TM-788) WIGL3: A PROGRAM FOR THE STEADY-STATE AND TRANSIENT SOLUTION OF THE ONE-DIMENSIONAL, TWO-GROUP, SPACE-TIME DIFFUSION EQUATIONS ACCOUNTING FOR TEMPERATURE, XENON, AND CONTROL FEEDBACK. Vota, A. V.; Curlee, N. J. Jr.; Henry, A. F. (Bettis Atomic Power Lab., Pittsburgh, Pa.). Feb. 1969. Contract AT(11-1)-Gen-14. 69p. Dep. CFSTI.

A description is given of WIGL3, a program for the steady-state and transient solution of the one-dimensional, two-group, space-time diffusion equations with zero, one or six delayed neutron groups. The program will treat slab, cylindrical and spherical geometries and includes non-boiling heat transfer. Xenon feed-

back and feedback effects due to fuel and coolant temperature are accounted for. Control rod motion and control system feedback based on total core power or outlet coolant temperature can be simulated. Transients may be excited by prescribed changes in inlet coolant temperature, coolant flow rate, or rod position. For the steady-state option, criticality may be achieved by adjusting control rod position, reference coolant density, or reference fuel temperature. The governing equations and a description of the input and edit features of the program are included. (auth)

**19553** DETAILED ANALYSIS OF MEASUREMENT OF THE DANCOFF CORRECTION. Fukai, Y.; Mizuta, H. (Nippon Atomic Industry Group Co., Kanagawa, Japan). Nukleonik, 12: No. 1, 12-17(Dec. 1968).

Hardy et al. (Nucl. Sci. Eng., 12: 301(1962)) have shown that the Dancoff correction in lattices is equal to the experimental results given in the following form; $R = (S^*-V^*)/V^* + (S-V)/V$, where starred and unstarred quantities refer to the "lattice" and "isolated" measurement, respectively, and S and V are the amount of epicadmium resonance neutron absorption per atom at rod surface and center, respectively. Using the RICM code which calculates the resonance integral in a multi-region lattice, this equality of R to the Dancoff correction was quantitatively investigated. After the effects of the slowing down model, the thickness of the surface resonance region in the fuel rod, and the fuel density on the quantity R are discussed, it is shown that a relation of R to the Dancoff correction $G_\infty$ can be expressed as $R = G_\infty + (1 - G_\infty)/(7.066 - 1.761G_\infty)$ with the fitting error of ±0.1%. According to the method for calculating the Dancoff correction for the fuels with cladding in the lattice, which have been suggested by the authors, $G_\infty$ is obtained and the values of R are calculated and compared with the experimental results of Hardy et al. The agreement is fairly good. In conclusion, the equivalence between R and $G_\infty$ does not accurately hold. The overestimated $G_\infty$ value of Hardy et al. seems to have led them to the equivalence. An alternative quantity $R^*$, defined as $R^* = (S^0 - V^0)/(S - V)$, is also calculated and discussed, where $S^0$ and $V^0$ are $S^*$ and $V^*$ without the flux lethargy-tilt effect, respectively. It is found that $R^*$, rather than R, is closer to $G_\infty$. Since it would be difficult to normalize the ($S^*$, $V^*$) and (S, V) which are measured separately and to correct the lethargy-tilt effect, $R^*$ could not be directly measured. Thus the Dancoff correction might not be experimentally obtained without any systematic errors. (auth)

**19554** METHOD FOR CALCULATING SPACE-DEPENDENT REACTOR SOURCE TRANSFER FUNCTIONS WITH FEEDBACK. Bridges, D. N.; Clement, J. D.; Renier, J. P. (Georgia Inst. of Tech., Atlanta). Nucl. Sci. Eng., 36: 122-5(Apr. 1969).

A technique is described which extends a previous method by which statics techniques were used to calculate source transfer functions with multigroup, multidimensional analysis for a zero-power reactor to include power feedback effects. The method described is based on two-group diffusion theory with temperature feedback. 7 references. (H.D.R.)

**19555** APPLICATION OF STATISTICAL THEORY AND MULTILEVEL FORMALISM TO DOPPLER EFFECT ANALYSIS. I. Hwang, R. N. (Argonne National Lab., Ill.). Nucl. Sci. Eng., 36: 67-81(Apr. 1969).

As a part of a series of studies now under way, the analytical aspect of the problems encountered in the application of multilevel formalism to the fast reactor Doppler effect analysis in the unresolved region is discussed. The concept of the "statistical collision matrix" introduced by Moldauer was used. The formulation and statistical consideration of the problem is described. For S-matrix formulation, the Doppler broadened cross sections using ideal gas model can be expressed in terms of the well-known broadened line shape functions. These functions are readily amenable for reactor calculations using any existing resonance integral code with some trivial modifications. The statistical behavior of the S-matrix parameters is also discussed in some detail. In order to improve understanding of the nature of the problem, an illustrative example was carried out analytically for the case of two interfering levels. Two more realistic examples pertinent to the fissile isotopes of interest are also given by numerical calculations using 50 interfering levels. These examples provide good qualitative descriptions of the statistical behavior of the S-matrix parameters that one may expect in the reactor Doppler effect studies. Part II deals with the application of the multilevel formalism in the Doppler effect studies. 31 references. (auth)

**19556** APPLICATION OF STATISTICAL THEORY AND MULTILEVEL FORMALISM TO DOPPLER EFFECT ANALYSIS. II. Hwang, R. N. (Argonne National Lab., Ill.). Nucl. Sci. Eng., 36: 82-96(Apr. 1969).

As the second part of a series, the application of the statistical theory and multilevel formulation to the reactor Doppler effect studies is described. Analytical studies were carried out on the basis of the narrow resonance approximation. The studies were made in both the high-energy and the intermediate-energy regions, which are of great interest in fast reactor Doppler effect calculations. Some qualitative conclusions on the influence of the multilevel interference effect on the Doppler effect of fissile isotopes are also given. 12 references. (auth)

**19557** COMPARISON OF MODAL AND ITERATIVE APPROACHES TO SPACE AND SPACE–TIME NONLINEAR PROBLEMS. Shotkin, Louis M. (Brookhaven National Lab., Upton, N. Y.). Nucl. Sci. Eng., 36: 97-104(Apr. 1969).

Solutions obtained by expansion in a series of spatial modes and by an iterative method are compared for both space and space-time problems. In the space problem, the modal expansion is used to justify the iterative results. A useful nonlinear transformation is introduced to aid in solving multimode approximations. The space-dependent fast adiabatic excursion model, or Fuchs-Nordheim model, is solved by a novel iterative approach. This iterative solution is valid for large disturbances, as well as small, thus improving results obtained by approximate modal expansions. The derivation of the space-independent Fuchs-Nordheim model from the space-dependent equation is shown to follow in a more straightforward manner than derivations based on modal approximations. 15 references. (auth)

**19558** EFFECTIVE EPITHERMAL ABSORPTION CROSS-SECTION FOR NEUTRON TRANSMISSION WITH THIN 1/v ABSORBER. Fritzsch, E. (Physikalischen Institut der Bergakademie, Freiberg, Ger.). Kernenergie, 11: 292-5(Nov.-Dec. 1968). (In German).

The epithermal transmission of a 1/v absorber and a 1/v detector in a collimated neutron beam may be approached by an exponential law when using an adequately defined effective epithermal absorption cross-section. For 1/v absorbers obeying the condition $\Sigma_a(\epsilon_1)d \leqq 0.3$ the deviation between approximation and exact value is less than 0.4 per cent, and less than 0.05 per cent for $\Sigma_a(\epsilon_1)d \leqq 0.1$. The effective epithermal absorption cross-section depends on the energy limits of the neutron spectrum and on the parameter of the detector $\Sigma_r(\epsilon_1)D$; it is always smaller than the absorption cross-section of the absorber near the lower limit of energy. (auth)

**19559** METHODS FOR STUDYING SPACE-DEPENDENT REACTOR DYNAMICS. Hsu, Chun; Mulcahey, Thomas P. Reactor Fuel-Process. Technol., 11: 172-9(Fall 1968).

DIFFERENTIAL EQUATIONS—use in space-dependent analysis of reactor dynamics, comparison of methods and models for
REACTORS—kinetics for, mathematical methods and models for analysis of space-dependent (D.C.C.)

**19560** MEASUREMENT OF NEUTRON FLUX SPECTRA BY A MULTIPLE FOIL ACTIVATION ITERATIVE METHOD AND COMPARISON WITH REACTOR PHYSICS CALCULATIONS AND SPECTROMETER MEASUREMENTS. McElroy, W. N. (Battelle Memorial Inst., Richland, Wash.); Berg, S.; Crockett, T. B.; Tuttle, R. J. Nucl. Sci. Eng., 36: 15-27(Apr. 1969).

A multiple foil activation iterative method has been used to experimentally determine neutron flux spectra in various types of neutron environments. The method involves irradiation of a set of different foil detectors, measurement of resultant activities, and adjustment of a spectrum selected as an initial approximation to obtain a good-fit solution for a set of simultaneous activation integral equations. A computer code, SAND-II, is used to obtain this solution. Spectra from thermal and fast reactors and from beam sources have been measured. In each experiment, a set of more than ten foil detectors, encompassing low- and high-energy neutron-induced reactions, was irradiated and used as input to SAND-II. Solutions obtained are compared with diffusion, transport, or Monte Carlo calculations or with spectrometer measurements. It is concluded that the multiple foil activation iterative method is an important adjunct to calculational and neutron spectrometer techniques used to determine neutron flux spectra. 40 references. (auth)

**19561** RESONANCE INTEGRAL AND DOPPLER COEFFICIENTS IN NONUNIFORM CYLINDRICAL REACTOR FUEL RODS. Van Binnebeek, J. J. (Univ. Libre, Brussels). Nucl. Sci. Eng., 36: 47-58(Apr. 1969).

Two methods for evaluating the effects of nonuniformities in reactor fuel on resonance integrals are described. In the first method, the volume and the surface effects on the resonance integral are separated by dividing the rod into two homogenized regions and a general formalism is developed which is adequate for numerical computation. In the second method, which uses the moment technique of Cady and Clark, a generalization of the Nordheim equation, available for the study of any nonuniformity of the rod is presented. As an example, an analytical expression

for a uniform temperature equivalent to a parabolic distribution is given. 15 references. (auth)

**19562** SPACE-DEPENDENT REACTOR-NOISE FORMULATION UTILIZING MODAL EXPANSIONS. Danofsky, R. A. (Iowa State Univ., Ames). Nucl. Sci. Eng., 36: 28-38(Apr. 1969).

A space-dependent noise formulation is developed on the basis of the modal-analysis technique. Application of the method is illustrated by numerical calculations carried out for a one-dimensional model of a coupled-core Argonaut type reactor. It has been found that the suggested method may be readily used to calculate the auto- or cross-spectral-density functions of the neutron-level fluctuations for any of the group fluxes of a multienergy group calculation when the system is subjected to arbitrary stochastic input functions. Results obtained from the numerical calculations serve to illustrate the importance of the space dependence of the spectral functions and in particular the sensitivity of the cross-spectral-density function to the two points of observation. 20 references. (auth)

**19563** REACTIVITY RATE-CONSTRAINED TIME-OPTIMAL NEUTRON KINETICS. Moon, S. F.; Mohler, R. R. (Univ. of New Mexico, Albuquerque). Nucl. Sci. Eng., 36: 125-8(Apr. 1969).

Minimal-time reactor control processes are analyzed with reactivity rate constraint considerations. The time-optimal reactivity variations to control the neutron kinetics from one equilibrium state to another and from an equilibrium state to a desired terminal neutron density are calculated. (H.D.R.)

## *Experimental Applications*

**19564** (ANL-7502) COOLANT-STRUCTURE COUPLING DURING A RAPID INSERTION OF ENERGY. Narasimhan, K. Y. Rosenberg, G. S.; Wambsganss, M. W. Jr. (Argonne National Lab., Ill.). Oct. 1968. Contract W-31-109-eng-38. 44p. Dep. CFSTI.

The results of a series of preliminary studies are presented which lead to an eventual assessment of the influence of the bounding structure on the results of out-of-pile coolant-dynamics investigations. The application of the results of these investigations to an actual reactor is described. It is postulated that the bounding structure can couple with the coolant dynamics and, acting as an energy-absorbing mechanism, materially influence the characteristics and propagation of coolant transients following a disturbance. The studies demonstrate this coupling and its dependence on structural flexibility and geometry. 12 references. (auth)

**19565** (CONF-680909) PROCEEDINGS OF THE LIVERMORE ARRAY SYMPOSIUM, SEPTEMBER 23-25, 1968, LIVERMORE, CALIFORNIA. (California Univ., Livermore. Lawrence Radiation Lab.). 121p. Dep. CFSTI.

Separate abstracts are prepared for each of the 15 articles on neutron interactions in arrays of fissionable material. Both calculational and experimental aspects are covered. (M.L.S.)

*For abstracts of individual papers see: 19511, 19548, and 19566-19578.*

**19566** (CONF-680909-, pp 6-11) DENSITY-ANALOG TECHNIQUES. Paxton, H. C. (Los Alamos Scientific Lab., N. Mex.).

Procedures and working equations for determining critical mass by the density-analog technique are given. The development of the density-analog technique is traced from the early LASL days to the present; modifications are evaluated. The surface density rule for stored fissile material is described; some storage limits are tabulated. 5 references. (M.L.S.)

**19567** (CONF-680909-, pp 18-25) SOME CONSIDERATIONS IN REGARD TO THE DEVELOPMENT AND USE OF THE KENO PROGRAM. Crume, E. C. Jr. (Union Carbide Corp., Oak Ridge, Tenn. Y-12 Plant).

Problems with reactor physics calculations for a nonreducible three dimensional geometry are summarized. The development of the KENO Monte Carlo program as a solution to these problems is discussed. The shortcomings of the 05R programs are mentioned with respect to three dimensional systems and criticality conditions of a system. Uses or applications of the KENO program are listed. Criticality determinations using the KENO are described; KENO calculated $k_{eff}$ values for bare and paraffin reflected enriched uranium systems are tabulated. Computer calculation times are given. 6 references. (M.L.S.)

**19568** (CONF-680909-, pp 26-7) THE DEVELOPMENT OF KENO, A MULTIGROUP MONTE CARLO CRITICALITY PROGRAM. Whitesides, G. E. (Union Carbide Corp., Oak Ridge, Tenn. Computing Technology Center).

The mathematical and physical foundations of the KENO multigroup Monte Carlo program are described. Times required for obtaining $k_{eff}$ via KENO calculations are compared to computer times required for other $S_n$ programs. (M.L.S.)

**19569** (CONF-680909-, pp 28-9) COLLISION PROBABILITY CALCULATIONS OF MULTIPLICATION FACTORS FOR LATTICES. Hunt, D. C. (Dow Chemical Co., Golden, Colo. Rocky Flats Div.).

A method for finding multiplication factors of unmoderated-unreflected one dimensional lattices is described. Conditions affecting the calculation are discussed; the method for tracing neutron collisions is outlined. (M.L.S.)

**19570** (CONF-680909-, pp 30-41) APPROXIMATE METHOD FOR CALCULATING INTERACTION. Clark, H. K. (Du Pont de Nemours (E. I.) and Co., Aiken, S. C. Savannah River Lab.).

A technique for reactor cell or lattice calculations is detailed. The assumptions which allow formulation of the problem are tabulated; the theoretical bases for these assumptions are outlined. Analytical expressions for the angular and surface distributions of the neutron currents are derived; neutron transmission probabilities are formulated. The method is extended to include multiple reactor cells or lattice groups; systems of equations describing current exchange are given. The probability of transmission for a reflected array of N units is derived; results of calculations are correlated with experiment. A numerical example is included. 6 references. (M.L.S.)

**19571** (CONF-680909-, pp 42-57) THE SURFACE-DENSITY METHOD: A SIMPLE MEANS FOR DESCRIBING CRITICAL INTERACTING ARRAY PARAMETERS. Gutman, Thomas (Westinghouse Electric Corp., Cheswick, Pa. Nuclear Fuel Div.).

The surface density method for evaluating interacting arrays of fissile material is described. Application to both metal and solution arrays is discussed. Sample calculations and examples are given; working equations are included. Critical weight, average material thickness, and critical volumes are shown graphically. Critical mass is shown as a function of average material thickness for cubic and infinite planar arrays. 15 references. (M.L.S.)

**19572** (CONF-680909-, pp 58-66) SOME EXPERIENCES WITH 05R MONTE CARLO. Webster, J. Wallace (Oak Ridge National Lab., Tenn.).

Use of the 05R program to calculate critical parameters of fissile assemblies or interacting arrays is discussed. The calculational procedures for $k_{eff}$, neutron flux, fission spectrum, average cosine of the scattering angle, and average energy loss per collision are described; calculations are tabulated. Comparison of critical experiments with Monte Carlo calculations are tabulated. Statistical errors resulting from Russian roulette are discussed; error evaluations are tabulated. Effect on $k_{eff}$ of number of subgroups per supergroup is evaluated. FORTRAN routines used for neutron history analysis are listed. (M.L.S.)

**19573** (CONF-680909-, pp 67-78) REMARKS ON ARRAY CRITICALITY TECHNIQUES. Thomas, J. T. (Union Carbide Corp., Oak Ridge, Tenn. Computing Technology Center).

Bases and philosophies behind array criticality measurements are discussed. Neutron leakage from individual units and arrays of units is discussed; effects of neutron leakage on neutron multiplication are shown. Uranium density in an array is shown as a function of the unit multiplication factor; plutonium or uranium density in an array is shown as a function of number of spherical units in a reflected critical array. Density-scaled arrays are discussed; Monte Carlo calculations are tabulated. Array shape effects are discussed; comparison of arrays with various h:d ratios are tabulated. 7 references. (M.L.S.)

**19574** (CONF-680909-, pp 80-2) SOLID ANGLE METHOD OF SPACING. Newlon, C. E. (Oak Ridge Gaseous Diffusion Plant, Tenn.).

The solid angle method of assembling arrays of fissile material is described. The criticality factor for an array of identical and nonidentical units is given. Safe interaction, in steradians, is shown for specified multiplication factors. 4 references. (M.L.S.)

**19575** (CONF-680909-, pp 84-91) INFINITE ARRAYS IN DIFFUSIVE MEDIA. Lewis, W. B. (Phillips Petroleum Co., Idaho Falls, Idaho).

Determination of criticality parameters for arrays of fissile material in diffusive media is discussed. Application of one-dimensional, two-group, two-region diffusion theory to mathematical simulation of these arrays is described. The mathematical model is detailed. The two group diffusion theory model is extended from diffusive media to air. (M.L.S.)

**19576** (CONF-680909–, pp 92-5) RESONANCE ABSORPTION BY STRONGLY INTERACTING BODIES. Amster, Harvey J. (California Univ., Berkeley. Dept. of Nuclear Engineering).

One dimensional neutron transport theory is used to describe resonance absorption in tightly packed lattices; the equations are formulated; assumptions are listed. Effects of interaction between units is determined by considering the absorption by each resonance as a negative source covering a narrow energy width. (M.L.S.)

**19577** (CONF-680909–, pp 96-107) THE INTERACTION BETWEEN POISONED AND UNPOISONED ELEMENTS IN A PERIODIC SLAB-CELL ARRAY. Rothe, Robert E. (Dow Chemical Co., Golden, Colo. Rocky Flats Div.).

The DTF-IV transport code is used to evaluate the interaction between B-poisoned slabs and U solution slabs when arranged in an infinite periodic array. The calculated results are compared with experimental results from a system closely approximating the one calculated. The experimental poison slabs are stainless-steel plates containing 1.02 wt % B; the U solution contains 450.8 g U(93.19 wt %) per liter. Two apparent failures of transport codes to produce physically possible results are cited. 8 references. (auth)

**19578** (CONF-680909–, pp 108-12) LIVERMORE PLUTONIUM ARRAY PROGRAM. Finn, H. F.; Pruvost, N. L. (California Univ., Livermore. Lawrence Radiation Lab.).

Experimental Pu criticality studies are described; diagrams, dimensions and material compositions for the critical assembly are given. Critical separation and 05R calculated values for $k_{eff}$ are tabulated. (M.L.S.)

**19579** ON THE STEP-RESPONSE METHOD OF DETERMINING THE ZERO-POWER REACTOR TRANSFER FUNCTION. Chapin, D. M. (MPR Associates, Inc., Washington, D. C.). Nucl. Sci. Eng., 36: 113-14(Apr. 1969).

Several aspects and advantages of determining the zero-power transfer function by the use of step-reactivity input are discussed. 14 references. (H.D.R.)

## Reactor Components, Fuels, and Accessories

*Refer also to abstracts 17541, 17544, 17545, 17624, 17672, 17785, 17815, 17825, 17831, 17832, 17834, 18185, 18200, 18203, 18204, 18259, 18267, 18270, 18282, 18285, 19461, and 19462.*

**19580** (BNL-50120(Pt.1), pp 123-33) CONTROL SYSTEM PHILOSOPHY FROM THE NUCLEAR REACTOR FIELD. Pearson, A. (Atomic Energy of Canada Ltd., Chalk River (Ontario). Chalk River Nuclear Labs.).

Various redundancy techniques which apply only to control systems are discussed. The introduction of digital computer philosophy for reactor control is also presented. (B.G.D.)

**19581** (IDO-17295) PARAMETRIC STUDIES OF FUEL PIN TEMPERATURE RESPONSE. Jensen, S. E. (Phillips Petroleum Co., Idaho Falls, Idaho. Atomic Energy Div.). Feb. 1969. Contract AT(10-1)-205. 41p. Dep. CFSTI.

A study was made to evaluate the influence of several parameters on the temperature response of a reactor fuel pin to expected loss-of-coolant accident conditions for system blowdown and core heat-up. The parameters considered were: the thermal conductivities and heat capacities of $UO_2$ fuel and Zircaloy-4 cladding; the effective conductance of the fuel pellet-cladding gap; fuel power density; and blowdown heat transfer coefficients. Blowdown heat transfer and effective gap conductance were found to be the parameters having greatest influence on fuel pin temperature response. Variations in the values used for thermal conductivity and heat capacity of $UO_2$ can also cause significant temperature variation. However, since more available data of less uncertainty exist for the values used for the $UO_2$ thermal properties than for the values used for blowdown heat transfer coefficients and effective gap conductance, future work should be concentrated on the latter parameters. 12 references. (auth)

**19582** (ORO-665, pp 9-29) BASIC PRINCIPLES OF U. S. FUEL SUPPLY POLICY. Kratzer, Myron B. (Atomic Energy Commission, Washington, D. C.).

Background on the general U. S. policy on international cooperation in peaceful uses of atomic energy is presented. Present U. S. fuel supply policies are described. (D.C.C.)

**19583** (ORO-665, pp 185-217) U. S. FUEL SUPPLY POLICIES: CONTRACTS AND SPECIFICATIONS. Panel Discussion.

The general types of U. S. enriching services or toll enriching contracts now available are described. The legal aspects concerning toll enrichment contracts as established by the USAEC are discussed. The termination rights of the USAEC and the enriching customer are described. Ceiling charges for enriching services are discussed. (D.C.C.)

**19584** NUCLEAR REACTOR. Terasawa, Shoichi (to Hitachi Ltd.). Japanese Patent 1968-25072. Oct. 29, 1968. Filed Nov. 17, 1964.

In the nuclear reactor proposed, fuel elements can be exchanged during the reactor operation. The fuel channel is a double-walled tube, both ends opening with regards to the space between the two tube-walls. Coolant water runs through the central hole of the double-walled tube. Fuel (or blanket) elements, in the form of a short cylinder but dividable in halves axially, are inserted in a series in the space between the two walls of the channel tube. By pushing the elements from one end of the channel tube, the halved fuel elements drop off at the other end. (NSA of Japan)

**19585** CONCENTRICALLY-ARRANGED CYLINDRICAL FUEL ELEMENTS. Nakai, Yasushi (to Mitsubishi Atomic Power Industry, Inc.). Japanese Patent 1968-26675. Nov. 15, 1968. Filed July 13, 1965.

By the method proposed, the thermal neutron flux in the upper part of the reactor core can be increased without changing the enrichment of fuel. The system consists of the following: upright cylindrical fuel elements of which the diameter decreases toward the bottom (control rods are inserted vertically from above) and arranged in concentric circles; an upright, large, hollow cylindrical body with both ends open located through the axial line of the reactor core; support grids at the top and at the bottom for the fuel elements and the cylindrical body; and nozzles for coolant water just out the top and the bottom support grid. (NSA of Japan)

**19586** IMPROVEMENTS IN SAMPLING A FLOW OF LIQUID. Bentley, Peter Graham; Taylor, Anthony Francis; Burton, Eric John (to United Kingdom Atomic Energy Authority). British Patent 1,144,569. Mar. 5, 1969. Filed June 9, 1965.

A sampling system for nuclear reactor coolant liquids is described which comprises apparatus providing a continuous sample. A feature of the system is that the sample is obtained from the liquid flow only after having been mixed at least twice and therefore rendered homogeneous. For a closed flow liquid circuit a reasonably homogeneous and representative sample can be achieved over a relatively short flow path, which is of particular value in nuclear reactors in connection with measurement of power output. In order to enable the overall power output of the core to be accurately determined it is desirable to know the mixed mean inlet and outlet temperatures of the coolant. Since mixing has occurred extensively in the coolant prior to entering the core a relatively small number of temperature measurements suffice to give a mixed mean inlet temperature. In order to determine the mixed mean outlet temperature, however, it is necessary to measure the individual mixed mean outlet temperatures of coolant in each fuel channel or a selected number of channels and then to compare individual temperatures to obtain an overall mixed mean value for the whole reactor. (UK)

**19587** A STUDY ON THE DISTRIBUTION OF HEAT-TRANSFER RATE IN ECCENTRIC DOUBLE-PIPE AND GROUPED TUBES. Tachibana, Fujio; Oyama, Akira (Tokyo Univ.). Collect. Lect., Jap. Heat Transfer Symp., 5th, 133-6(May 1968). (In Japanese).

With the increase in reactor-core power density, the fuel elements tend to be thinner and the distance between to be narrowed. In such fuel channels, it is important to obtain good heat-transfer characteristics and to keep localized temperatures below certain limits. In order to clarify the heat transfer characteristic in a fuel assembly, basic experiments were made by the naphthalene sublimation method with eccentric double pipe and grouped tubes. In the range of the experiment performed, the average heat-transfer rate with an ordinary fluid in eccentric double pipe and assembly can be estimated by Colburn's law. But, due to the existence of a secondary flow, the localized heat-transfer rate does not exactly agree with the theoretical, analytic value with complete parallel flow. For this reason, the experimental study is important. (NSA of Japan)

**19588** MECHANISM FOR EFFECTING THE POSITIONAL ADJUSTMENT OF NUCLEAR REACTOR CONTROL RODS. Vautrey, Louis (to Commissariat a l'Energie Atomique). U. S. Patent 3,432,047. Mar. 11, 1969. Priority date Oct. 22, 1965, France.

A nuclear reactor control rod positioning mechanism is described which comprises a control rod grab and a system of rods and levers to position and actuate the grab. The mechanism to

position the grab includes first and second vertical rods coupled by intermediate rods. The grab is attached to the end of the second vertical rod. The grab operating mechanism comprises first and second vertical rods coupled by an intermediate rod with the lower end of the second rod being coupled to a pusher cam system to operate the jaws of the grab. (Offic. Gaz.)

**19589** NUCLEAR REACTOR FUEL ELEMENTS. Ellington, John Peter (to United Kingdom Atomic Energy Authority). U. S. Patent 3,431,169. Mar. 4, 1969. Priority date Dec. 30, 1965, Great Britain.

A nuclear reactor fuel element is described which comprises sheathing exposed externally to flowing coolant and contains ceramic nuclear fuel whose density in aggregate is less than (for example, 85%) maximum theoretical density so as to provide distributed voidage. The fuel element has a solid interlayer having thermal insulating properties disposed in contact between sheathing and fuel. The interlayer contains no fissile or fertile atoms, and serves to increase the operating temperature of the fuel. This also lowers its compressive creep strength, whereby irradiation-induced swelling of the fuel is absorbed in the voidage. (Offic. Gaz.)

**19590** NUCLEAR REACTOR FUEL BUNDLE. Lass, James L.; Venier, Dominic A. (to General Electric Co.). U. S. Patent 3,431,170. Mar. 4, 1969. Filed Dec. 7, 1966.

A fuel bundle for a nuclear reactor comprising a plurality of fuel rods positioned between upper and lower tie plates is described. The upper tie plate is easily removable to permit interchange of the fuel rods. (Offic. Gaz.)

**19591** DEVICE FOR ASSEMBLING A NUCLEAR FUEL ELEMENT SUPPORT INSIDE AN ANNULAR SLEEVE. Le Coz, Francois; Raynaud, Noel (to Commissariat a l'Energie Atomique). U. S. Patent 3,431,618. Mar. 11, 1969. Priority date Mar. 30, 1965, France.

A device for assembling a nuclear fuel element support within an annular sleeve is described. The support consists of a cylindrical-shaped bracket at the base of the fuel element. At least 3 discs are uniformly spaced around the fuel element axis and are engaged between recesses formed in the cylindrical-shaped support bracket and a toxic groove in the sleeve. The weight of the fuel element on the support bracket holds the discs in position. The support bracket is inserted into the hollow sleeve by a plunger guided by blade springs. (Offic. Gaz.)

**19592** EQUIPMENT FOR COOLING OF THE FUEL IN A NUCLEAR REACTOR. Jenssen, S. K. (to Alfa-Laval AB). Swedish Patent 218,224. Jan. 16, 1968. Filed Mar. 4, 1964. (In Swedish).

Equipment for cooling the fuel rods in a reactor fuel element assembly is described. The flow of the cooling medium is both longitudinal and transversal. (Sweden)

**19593** A PRESTRESSED CONCRETE PRESSURE VESSEL FOR NUCLEAR REACTORS. Puyo, Andre; Thome, Paul (to Commissariat a l'Energie Atomique). British Patent 1,144,840. Mar. 12, 1969. Priority date Feb. 24, 1967, France.

CONCRETES—pressure vessels of prestressed, for reactors with integral heat exchangers
PRESSURE VESSELS—prestressed concrete, description of cylindrical reactor
REACTORS—pressure vessel for integral heat exchanger-type, description of cylindrical prestressed concrete (D.C.C.)

**19594** HIGHLY DEPENDABLE AUTOMATIC CONTROL FOR NUCLEAR REACTORS. Jover, Pierre (CEN, Saclay, France). Automatisme, 13: 502-9(Oct. 1968). (In French).

A triple control system for a high-flux nuclear reactor is described; in addition, a method for reliability tests is described for evaluation of the functioning of the system. Continuity of functioning is assured in case of the breakdown of a single line, and reliability for long-duration missions is improved by maintenance. Corrective maintenance, detection of active breakdowns, and preventive maintenance are outlined. The program for corrective maintenance renders reliability almost independent of duration; and replacement of weakening elements reduces the level of failures to a very low level. It is necessary to detect failure in an affected line immediately and to disconnect the line, reducing the triple to a double system, if decrease of power must be avoided; otherwise the system may run until the next repair period. (BBB)

**19595** APPARATUS FOR NUCLEAR REACTOR CONTROL. (to Atomic Energy of Canada Ltd.). British Patent 1,145,617. Mar. 19, 1969. Priority date July 8, 1966, Canada.

REACTOR CONTROL ELEMENTS—liquid, description of gas-pressure-regulated overhead-reservoir U-tube (D.C.C.)

**19596** PRESSURE SUPPRESSING ARRANGEMENT FOR USE WITH A NUCLEAR REACTOR. Weems, Sterling J.; Hinds, John A.; Mandil, I. Harry (to Westinghouse Electric Corp.). U. S. Patent 3,423,286. Jan. 21, 1969. Filed Feb. 18, 1966.

A nuclear reactor containment is provided wherein energy releasable from a nuclear reactor in the event of a failure is absorbed by a solid which melts at a temperature lower than the condensation temperature of the escaping vapor. In certain examples the solid is housed in cooled compartments which are exposed to the reactor system during accident conditions. (Offic. Gaz.)

**19597** METHOD OF MAKING NON-METALLIC SWAGED FUEL ELEMENTS. Baily, William E.; Colombo, Roberto L. (to Westinghouse Electric Corp.). U. S. Patent 3,429,025. Feb. 25, 1969. Filed Mar. 17, 1964.

Fuel elements are prepared by disposing a nuclear fuel material in a sheath, swaging the sheath to achieve a desired density, and then heat treating the sheathed material. (Offic. Gaz.)

**19598** PROCESS FOR FABRICATING NUCLEAR REACTOR FUEL ELEMENTS. Kling, Harry P. (to Martin Marietta Corp.). U. S. Patent 3,422,523. Jan. 21, 1969. Filed June 26, 1963.

Nuclear fuel elements are fabricated by sealing a sintered fuel material in an evacuated foil envelope. The foil envelope is clad and formed into a tube. The tube is then drawn to a desired smaller size. (Offic. Gaz.)

**19599** TEMPERATURE CONTROL FOR A NUCLEAR REACTOR. Currey, Charles F.; Rydin, Roger A. (to Westinghouse Electric Corp.). U. S. Patent 3,423,285. Jan. 21, 1969. Filed Jan. 27, 1966.

In a control system for a nuclear reactor primary coolant loop, a reference temperature signal is compared with an actual temperature signal and the reactivity of the reactor is varied in accordance with the difference in magnitude of the signals. The reference signal is provided to be of varying magnitude over a substantial portion of the heat removal range of the reactor load means. (Offic. Gaz.).

**19600** FUEL ELEMENT BUNDLE FOR NUCLEAR REACTORS. (to Gesellschaft fuer Kernforschung mbH). British Patent 1,146,779. Mar. 26, 1969. Priority date Apr. 2, 1966, Germany.

REACTOR FUEL ELEMENTS—assemblies of multiple rod-shaped dumbbell-grouped, description of helical-flow-inducing multiple offset vertical-stacked (D.C.C.)

**19601** NUCLEAR REACTOR FUEL ELEMENT SUPPORT. Anthony, Andrew J.; Viets, Adolph W. Jr. (to Combustion Engineering, Inc.). U. S. Patent 3,423,287. Jan. 21, 1969. Filed Sept. 21, 1965.

A fuel element support grid for a bundle-type fuel element assembly is described. Bent members extend at right angles to each other to form a lattice for multiple parallel tube-type fuel elements. The bent members have spring-type projections which form 2 adjacent walls of each lattice compartment. The projections are formed from thin metal bands. (Offic. Gaz.)

# GENERAL

**19602** (AAEC/TM-494) AELINK: AN INDEPENDENT PROGRAM LINKING FACILITY FOR THE IBM 360. Mason, C. B.; Richardson, D. J. (Australian Atomic Energy Commission Research Establishment, Lucas Heights). Jan. 1969. 6p. Dep.

AELINK provides a generalized facility for controlling and linking together independent IBM 360 computer programs. Any number of independent programs may be run within the one job step under the dynamic control of a user-written Fortran or Assembler program. Any input-output discrepancies between the independent programs may also be resolved. (auth)

**19603** (AEC-tr-6820) NUKLEONIKA. Translation of Nukleonika, 12: 977-1080(1967). 98p. CFSTI.

**19604** (AECL-3225) VOLTAGE AND CURRENT CENTERING OF AN ELECTRON MICROSCOPE OBJECTIVE LENS. Ploc, R. A. (Atomic Energy of Canada Ltd., Chalk River (Ontario)). Dec. 1968. 30p. Dep. CFSTI. CAN $1.00.

An attempt was made to determine the method of aligning an electron beam relative to a non-ideal objective lens of an electron microscope which allows the attainment of maximum resolution. A simplified Gaussian optical treatment indicated that under normal conditions maximum resolution is achieved when the electron beam passes along the voltage axis of the lens. The presence of current and voltage axes was due to the non-ideal nature of the lens and to the presence of a combination of lenses respectively. (auth)

**19605** (ANL-7435) THE FORTRAN-PL/I INTERFACE PROBLEM. Matthies, Michael T. (Argonne National Lab., Ill.). Nov. 1968. Contract W-31-109-eng-38. 30p. Dep. CFSTI.

The implementation of two techniques that provide for the establishment of a FORTRAN-PL/I interface is described. This is not intended as a programmer's guide, but rather as a thorough discussion of the linkage and communication areas that allow PL/I and FORTRAN to be dynamically combined. The means for explicit and implicit passage of data types compatible to both languages is examined. This requires a study of two types of PL/I object time data-declaration blocks, namely, the string and array dope vectors. A brief discussion of the aspects of the internal control structures of PL/I and FORTRAN, related to linking the two languages, is also included. (auth)

**19606** (ANL-7507) GUIDE TO ACCESSING MULTIFILE MAGNETIC TAPES FROM FORTRAN PROGRAMS UNDER OS/360. Chamot, Cynthia (Argonne National Lab., Ill.). Oct. 1968. Contract W-31-109-eng-38. 24p. Dep. CFSTI.

ASP, JCL, and FORTRAN specifications for creating and retrieving information on multifile magnetic tapes are presented. Also included are samples of DD cards that work, and lists of error indications that are obtained when these specifications are not followed. The emphasis is on using a different data set reference number for each file on tape to facilitate accessing arbitrary files of information. (auth)

**19607** (ANL-7516) ARGONNE NATIONAL LABORATORY PUBLICATIONS, JULY 1, 1967-JUNE 30, 1968. (Argonne National Lab., Ill.). Nov. 1968. Contract W-31-109-eng-38. 357p. Dep. CFSTI.

A bibliography of scientific and technical literature (journal articles, technical reports, books, etc.) originated at Argonne National Laboratory and published during the fiscal year 1968. Author and KWOC (Key Word Out of Context) indexes are included. (B.G.D.)

**19608** (BNWL-987) BROWNIAN DIFFUSION OF SUBMICRON PARTICLES IN AIR UNDER NONEQUILIBRIUM CONDITIONS. Slinn, W. G. N. (Battelle-Northwest, Richland, Wash. Pacific Northwest Lab.). Feb. 1969. Contract AT(45-1)-1830. 50p. Dep. CFSTI.

Brownian diffusion of particles with Knudsen number large compared to one is analyzed both in equilibrium and nonequilibrium environments. For air in equilibrium it is shown, using only Newton's laws and the central limit theorem that for specular reflection of the molecules, equipartition is a consequence of the motion. For diffuse reflections the diffusion coefficient is found to depend upon the temperature of the particle and on the number of molecules reflected diffusely. This illustrates a limitation of the fluctuation-dissipation theorem. The motion of Brownian particles in air that is in thermal and translational nonequilibrium, is influenced by heat flux and viscous stress. A new force is described which is similar to that used to explain the thermophoresis effect but which depends upon the viscous stress. The solution is found to the new Fokker-Planck equation. In the generalized convective-diffusion equation, the diffusion coefficient appears as a second order tensor and contains the influence of the viscous stress tensor on diffusion. (auth)

**19609** (CEA-R-3534-1-E) BINARY ANALYSIS. FIRST PART. DEFINITIONS AND TREATMENT OF BINARY FUNCTIONS. Vallee, Rene-Louis (Commissariat a l'Energie Atomique, Saclay (France). Centre d'Etudes Nucleaires). Dec. 1968. 52p. Dep.

The study of binary groups under their mathematical aspects constitutes the matter of binary analysis, the purpose of which consists in developing altogether simple, rigorous, and practical methods needed by the technicians, the engineers, and all those who may be mainly concerned by digital processing. This subject which tends to play a main part in nuclear electronics as well as in several other research areas is discussed. (auth)

**19610** (DP-1181) SIMULATION MODEL OF AN IBM 360/65 JOB SHOP. II. Ludeman, M. M.; Knight, F. D. (Du Pont de Nemours (E. I.) and Co., Aiken, S. C. Savannah River Lab.). Feb. 1969. Contract AT(07-2)-1. 28p. Dep. CFSTI.

A simulation model of an IBM 360/65 computer job shop operating with a dynamic job scheduler is presented. The discussion includes a description of the system modeled, the design of the experiments made with the model, and an analysis of the results obtained. The model is written in BPSS/360. (auth)

**19611** IES/AIAA/ASTM THIRD SPACE SIMULATION CONFERENCE, SEATTLE, WASHINGTON, SEPTEMBER 16-18, 1968. Mt. Prospect, Illinois, Institute of Environmental Sciences, 1968. 230p. $11.00. (CONF-680947).

Separate abstracts were prepared for 6 of the 29 papers presented. The remaining 23 papers were not sufficiently within the scope of NSA. (W.H.K.)

*For abstracts of individual papers see: 17660, 17661, 17686, 17845, 18251, and 18252.*

**19612** (LA-4020(Suppl.2)) RDTRAN: MACHINE-DEPENDENT MODIFICATIONS FOR THE UNIVAC-1108. McDaniel, Roger D. Griffin, James H. (Los Alamos Scientific Lab., N. Mex.). Dec. 1968. Contract W-7405-eng-36. 17p. Dep. CFSTI.

RDTRAN is a computer program for translating and processing free-format input data. It is an interpretive system designed for use as the input translator of a problem-oriented source language, or as a general purpose free-format input loader. This document is a supplement to LASL report LA-4020 and contains a source language listing of the machine-dependent modifications for the UNIVAC-1108. (auth)

**19613** (NASA-SP-5070) TELEOPERATOR CONTROLS. An AEC-NASA Technology Survey. Corliss, William R.; Johnsen, Edwin G. (National Aeronautics and Space Administration, Washington, D. C.). Dec. 1968. 162p. Dep. CFSTI.

General purpose, dexterous, man-machine systems that augment man by projecting his manipulatory and pedipulatory capabilities across distance and through physical barriers into hostile environments are described. Teleoperator controls are discussed under the following headings: the control subsystem; control theory; the man-machine interface; teleoperator controls; displays; and contributions from teleoperator control technology. (R.C.K.)

**19614** (ORNL-4375) SPECIFIC CONDUCTANCE OF MOLTEN POTASSIUM NITRATE. Robbins, G. D.; Braunstein, J. (Oak Ridge National Lab., Tenn.). Mar. 1969. Contract W-7405-eng-26. 18p. Dep. CFSTI.

A careful determination of specific conductance of molten potassium nitrate over the temperature range 345 to 541°C demonstrated its suitability as a molten salt standard in electrical conductance work. The data are well represented ($\sigma$ = 0.0008) by the computer-fitted, least squares equation: $\kappa = -0.7098 + 4.6203 \times 10^{-3}\, t(°C) - 2.0221 \times 10^{-6}\, t^2$. The estimated accuracy is better than ±0.5%. Of the previous investigations on this system the limited temperature equation of Smith and Van Artsdalen agrees best with the results reported. (auth)

**19615** (SC-DR-69-12) ROLAMITE FOUR-PIECE CASE FABRICATION STATUS REPORT. Roth, E. S. (Sandia Labs., Albuquerque, N. Mex.). Feb. 1969. 17p. Dep. CFSTI.

The status of the processes developed to manufacture, inspect, selectively assemble, join, and then final inspect four-piece rolamite pumper cases is described. Enough piece parts have been manufactured and preinspected to assemble 50 cases within

a size range of 0.0005 inch and to tolerances of from ±0.000050 inch to ±0.0002 inch. Nine of these cases have been assembled and some are being used as mandrel molds. Since the design of the pumper case has changed since this development was started, the remaining cases may never be assembled. (auth)

**19616** (UCRL-50545) VELOCITIES OF FRAGMENTS FROM EXPLODING METAL CYLINDERS. Lee, Edward L.; Pfeifer, Harold (California Univ., Livermore. Lawrence Radiation Lab.). Jan. 6, 1969. 6p. Dep. CFSTI.

Calculations with one- and two-dimensional hydrodynamic codes were made to compare the results of end-surface and axial initiation of high explosives in cylindrical metal tubes. The comparison shows that for long tubes, the terminal fragment velocities resulting from the two modes of initiation are nearly identical. The important differences are found at HE length-to-diameter (L/D) ratios of less than 3, where the metal velocities calculated for axially initiated cylinders are significantly larger. (auth)

**19617** (UCRL-50558) OPERATING PROCEDURE FOR POCKELS CELL CHECKOUT. Pettipiece, Kenneth (California Univ., Livermore. Lawrence Radiation Lab.). Dec. 23, 1968. 7p. Dep. CFSTI.

Equipment for checking the quality and voltage requirements of Pockels cells is described. Test procedures and quality requirements of particular value to users of Pockels cells in laser applications are discussed. (auth)

**19618** SPECIFICATION FOR SYMBOL FOR IONISING RADIATION. British Standard 3510:1968. London, British Standards Institution, 1968. 6p. 4s.

A distinctive standard symbol to indicate the actual or potential presence of ionizing radiation is specified. (UK)

**19619** THE DEVELOPMENT OF A PARTICULATE RADIOACTIVE SOIL FOR DETERGENCY STUDIES. Gordon, B. E.; Bastin, E. L. (Shell Development Co., Emeryville, Calif.). J. Amer. Oil Chem. Soc., 45: 754-9(Nov. 1968).

The preparation and use of a sample of kaolinite clay tagged by neutron irradiation for detergent evaluation are described. After an extended cooling period (18 months) to allow the short-lived nuclides to decay, the clay was still sufficiently radioactive to use in detergency studies. Extraction tests showed that about 25% of the radioactivity was labile, i.e., removed by sodium tripolyphosphate, but that the remainder was strongly fixed in the clay matrix, resisting extraction by detergents. The clay had a number of nuclides emitting $\beta$ and $\gamma$ radiation. Analytical methods for both types of radiation were developed for use with fabrics and wash waters. The clay was combined with the doubly labeled fatty soil ($^{3}H$ and $^{14}C$) to make a triply labeled particulate soil. Tergotometer runs with 3 test fabrics showed good precision for the 3 labeled components of the soil. Redeposition measurements were also made and showed that a considerable fraction of the residual clay on the washed swatch may in fact be due to redeposition rather than retention. Some problems remain in the application of this synthetic soil: the padding step must be modified so that the clay is more tenaciously bound to the fabric; a more automatic method of padding is required to handle large numbers of samples; the specific activity of the clay should be increased so that liquid scintillation analysis for the 3 tagged components can be made on a single sample of wash water. (BBB)